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Okamoto et al.

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(54) **LIGHTING UNIT AND IMAGE SCANNER USING SAME**

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USPC 358/475, 474, 497, 498
See application file for complete search history.

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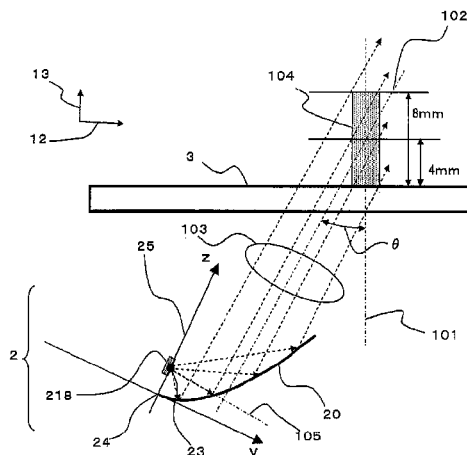
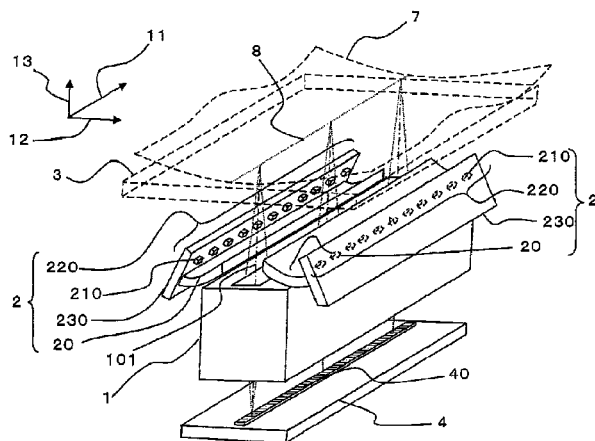
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(57) **ABSTRACT**

A lighting unit is provided with: LED arrays in which light-emitting elements are positioned in an array in a main scanning direction; cylindrical parabolic mirrors that project light emitted from the LED arrays on an illumination region of an illuminated item; and a housing that houses or holds the LED arrays and the cylindrical parabolic mirrors. Each cylindrical parabolic mirror forms a shape in which a cylindrical paraboloid having curvature with respect to a sub-scanning direction has been clipped by an axial plane that is perpendicular to the vertex of the cylindrical paraboloid in the main scanning direction. The LED arrays are positioned so as to include the focal position of the cylindrical paraboloid in the light-emitting region, the central axis in the light-emitting direction being perpendicular to the axial plane.

12 Claims, 25 Drawing Sheets



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H04N 1/03 (2006.01)
G02B 19/00 (2006.01)
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1/0285 (2013.01); **H04N 1/02865** (2013.01);
H04N 1/02895 (2013.01); **H04N 1/0305**
(2013.01); **G03B 27/54** (2013.01)

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FIG. 1

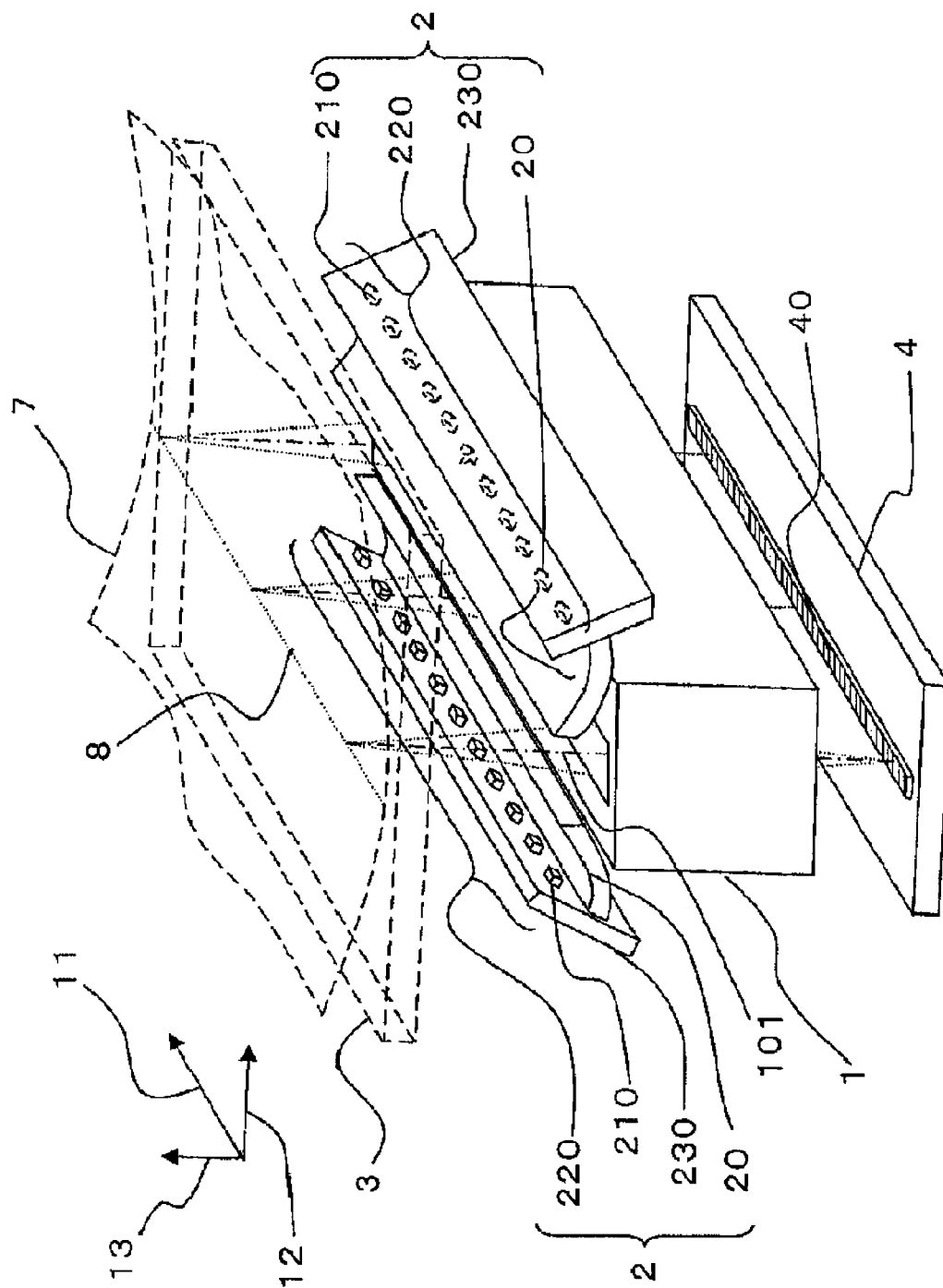
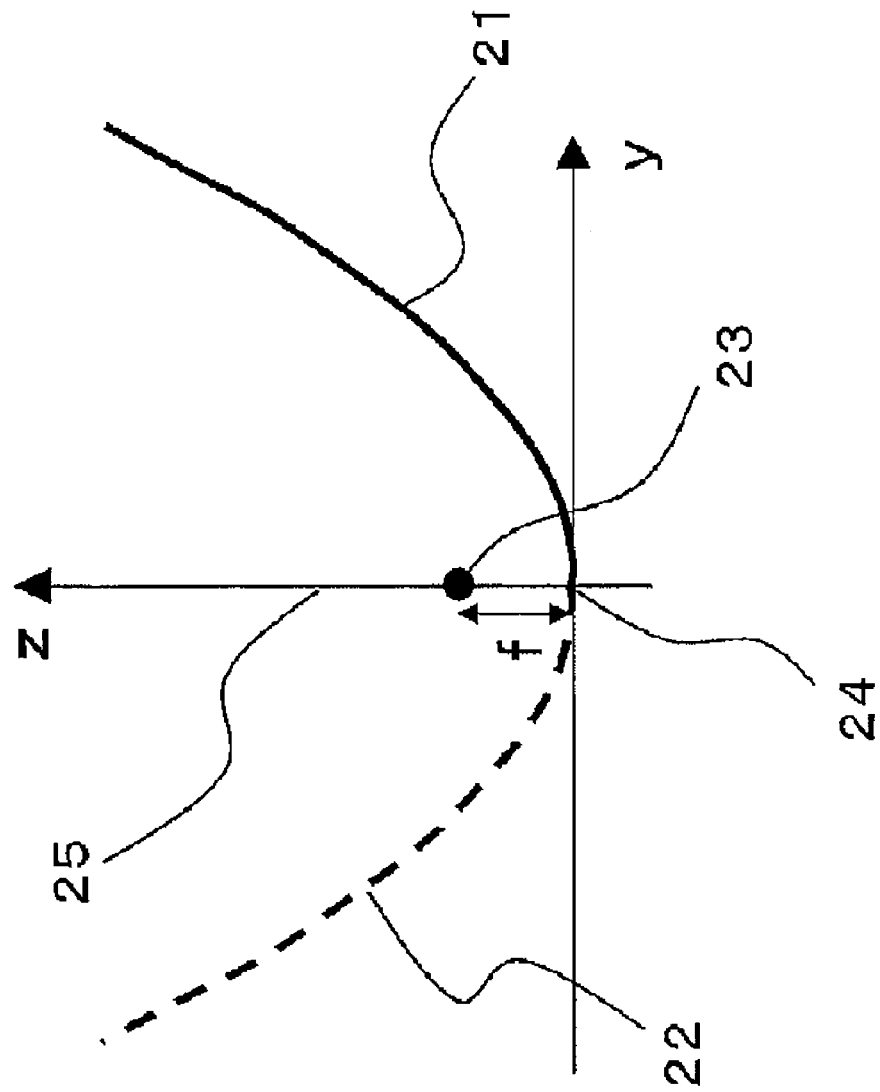


FIG.2



$$z = \frac{cy^2}{1 + \sqrt{1 - (1+k)c^2y^2}}$$

$$c = 1/R$$

$$f = R/2, k = -1$$

FIG. 3

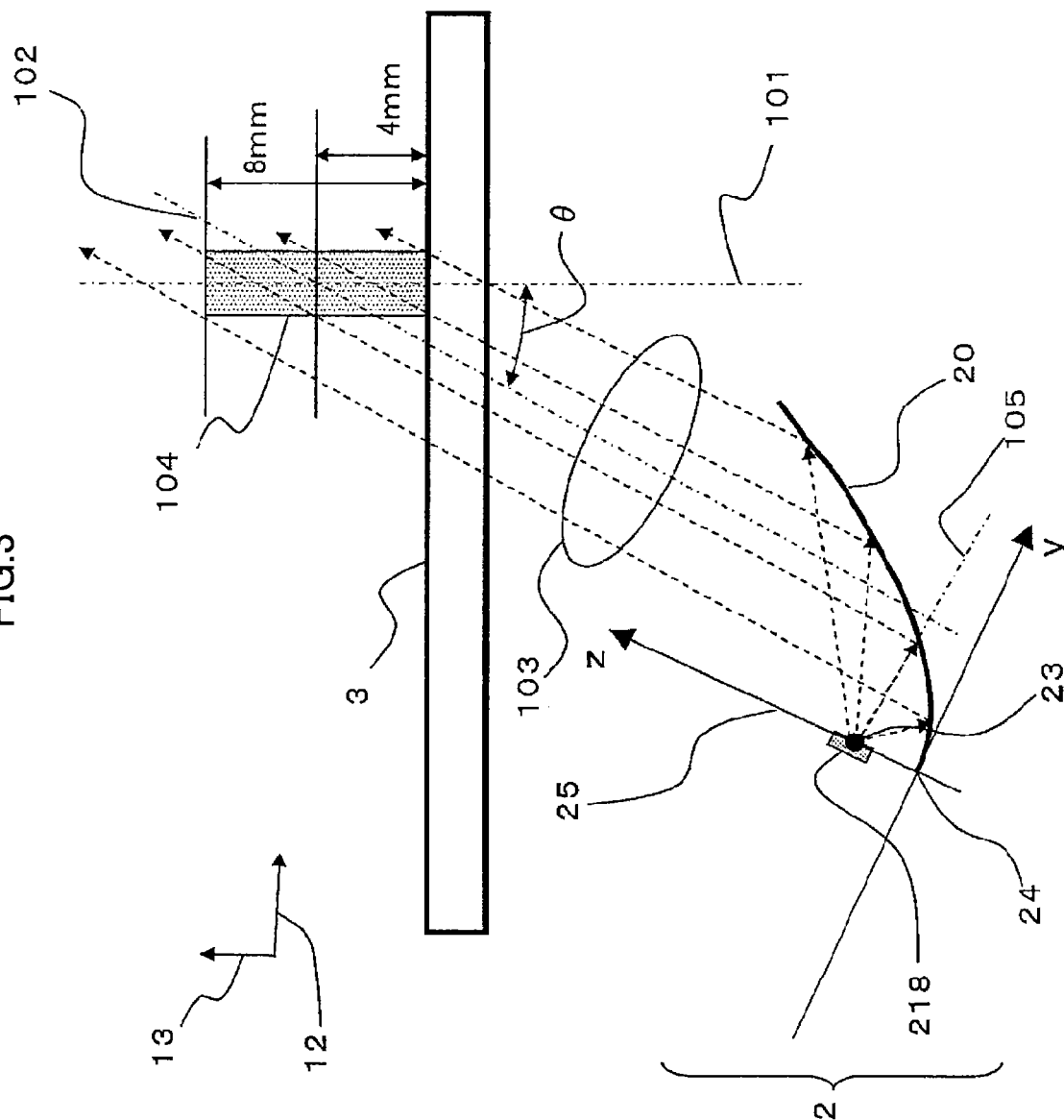
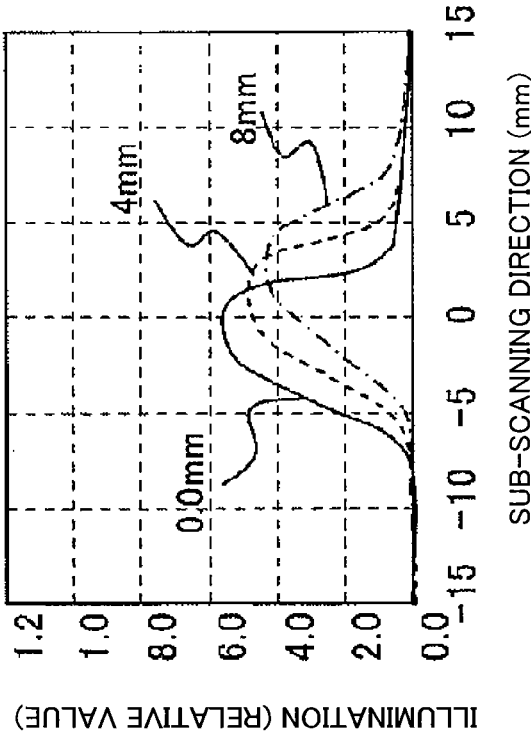
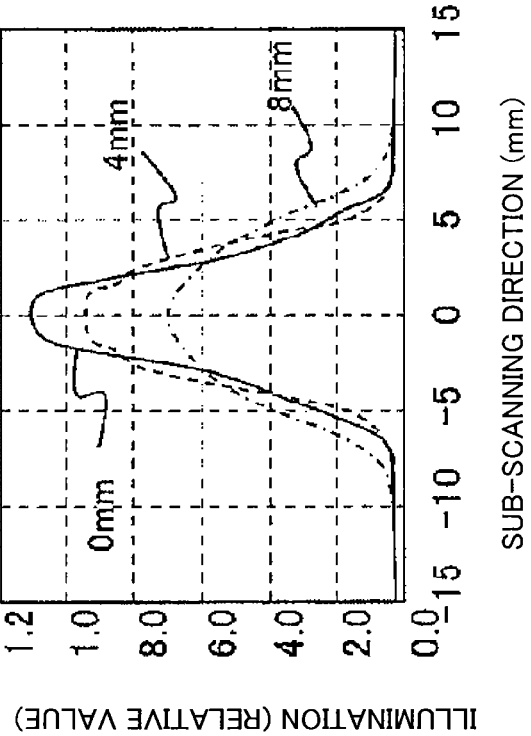


FIG. 4

DISTANCE FROM TOP SHEET SURFACE AND SUB-SCANNING DIRECTION
ILLUMINATION DISTRIBUTION



(a) ONE-SIDE LIGHTING SUB-SCANNING DIRECTION
ILLUMINATION DISTRIBUTION



(b) TWO-SIDE LIGHTING SUB-SCANNING DIRECTION
ILLUMINATION DISTRIBUTION

FIG. 5

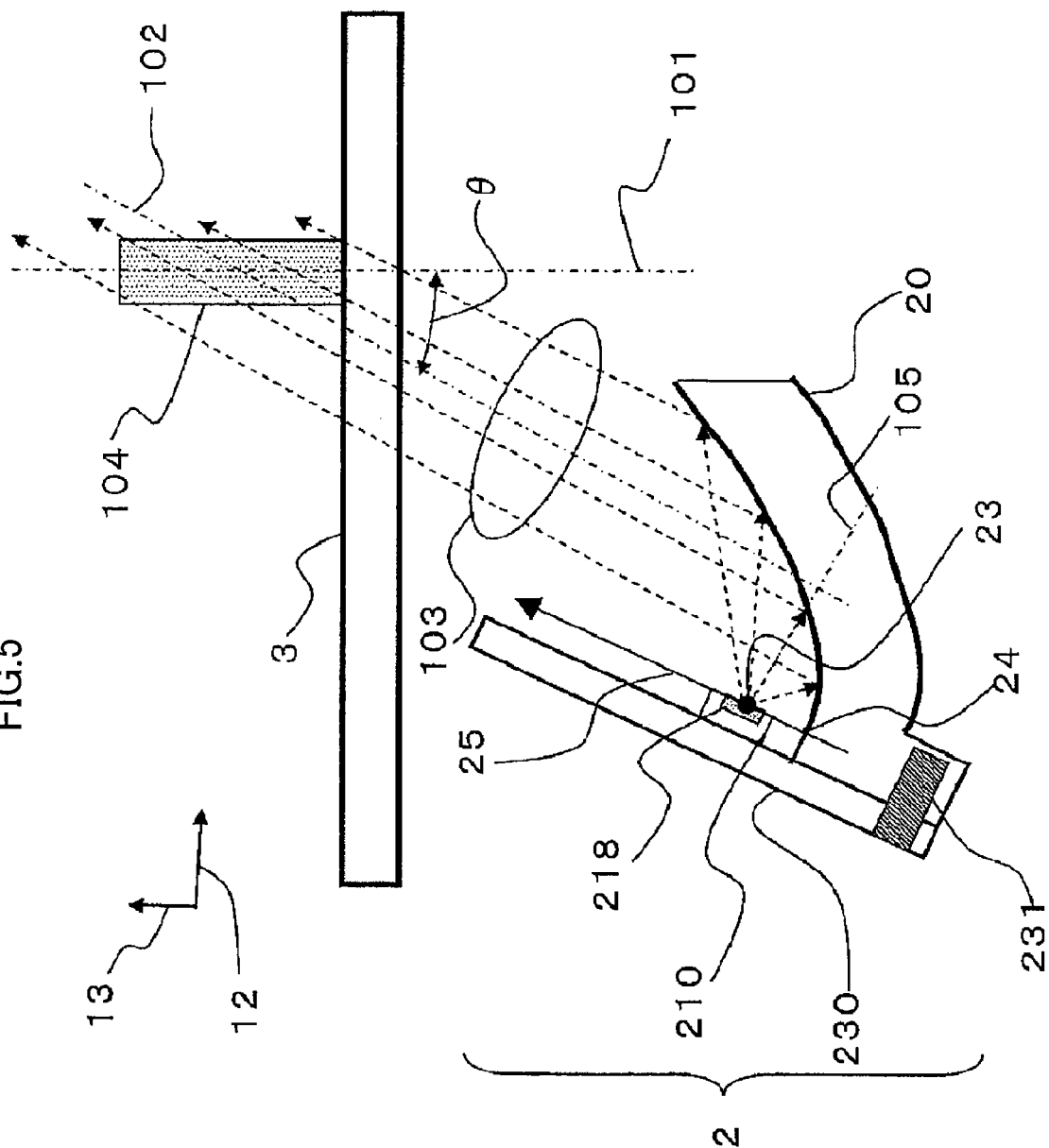


FIG.6

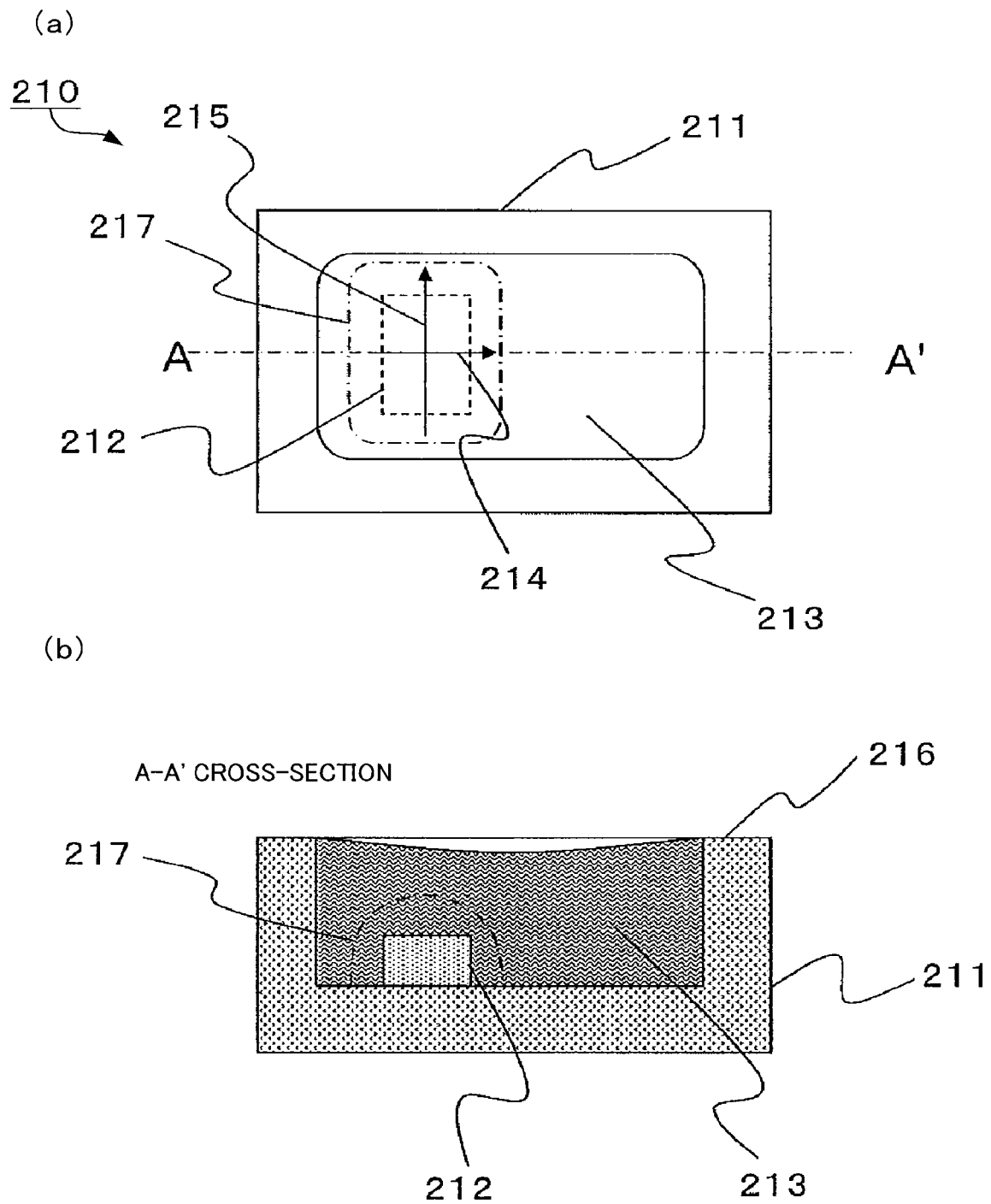


FIG. 7

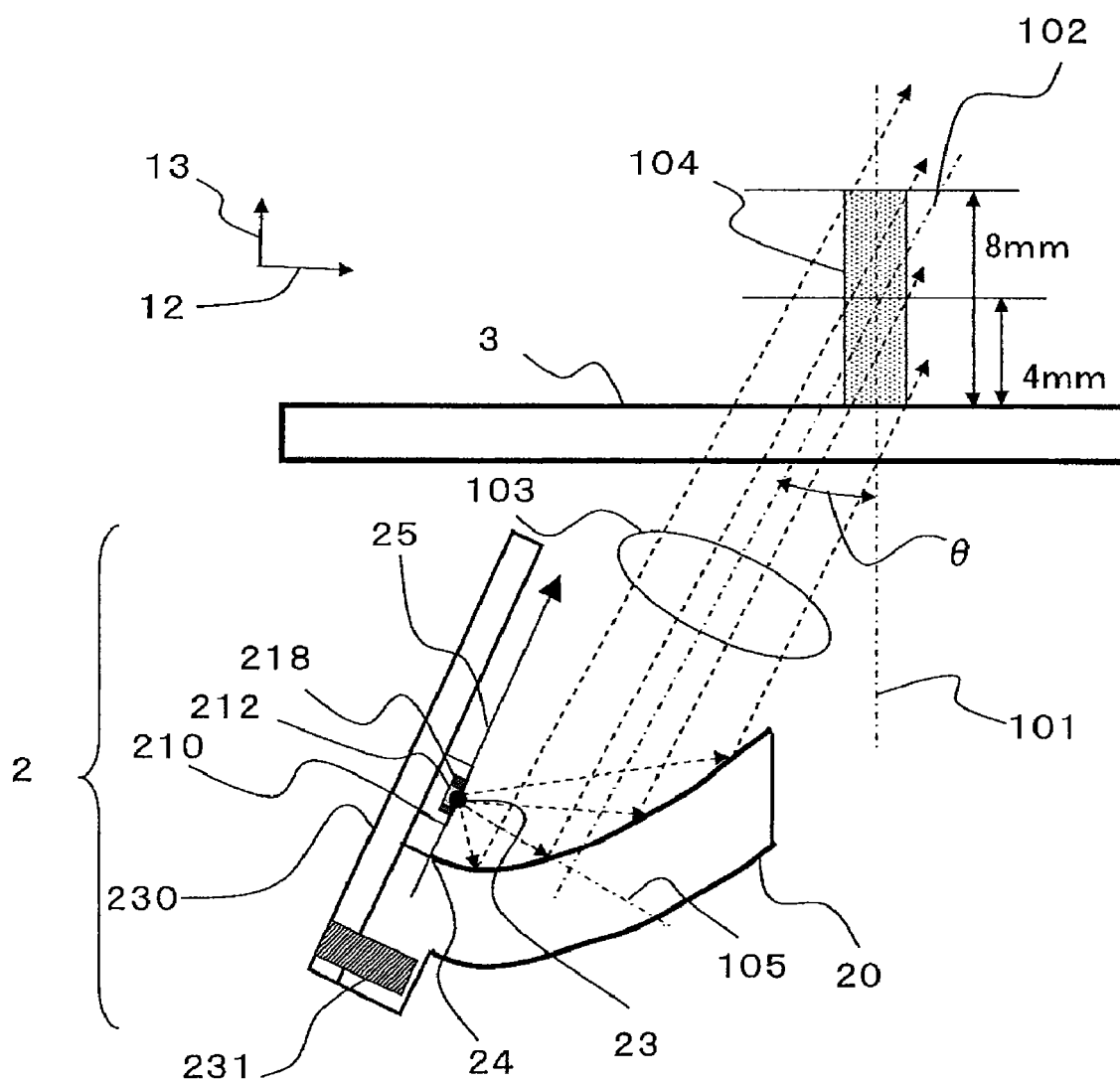


FIG. 8

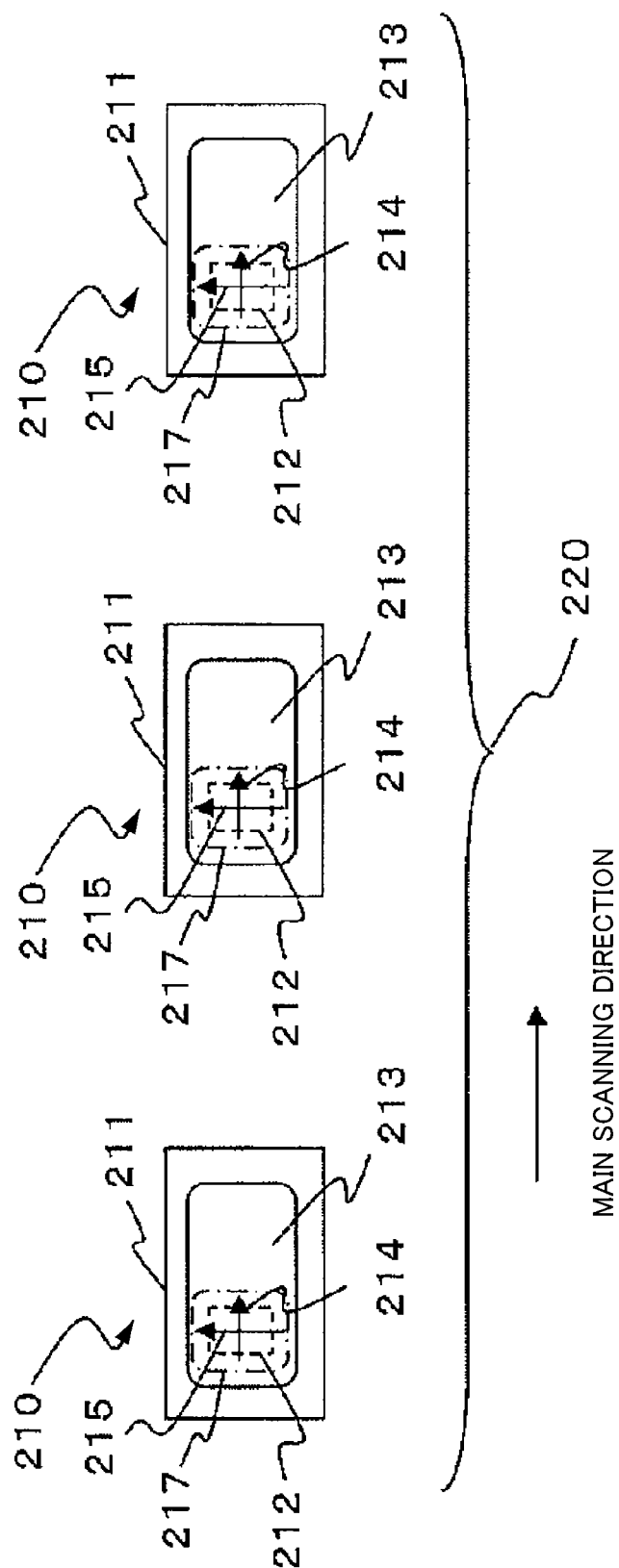


FIG.9

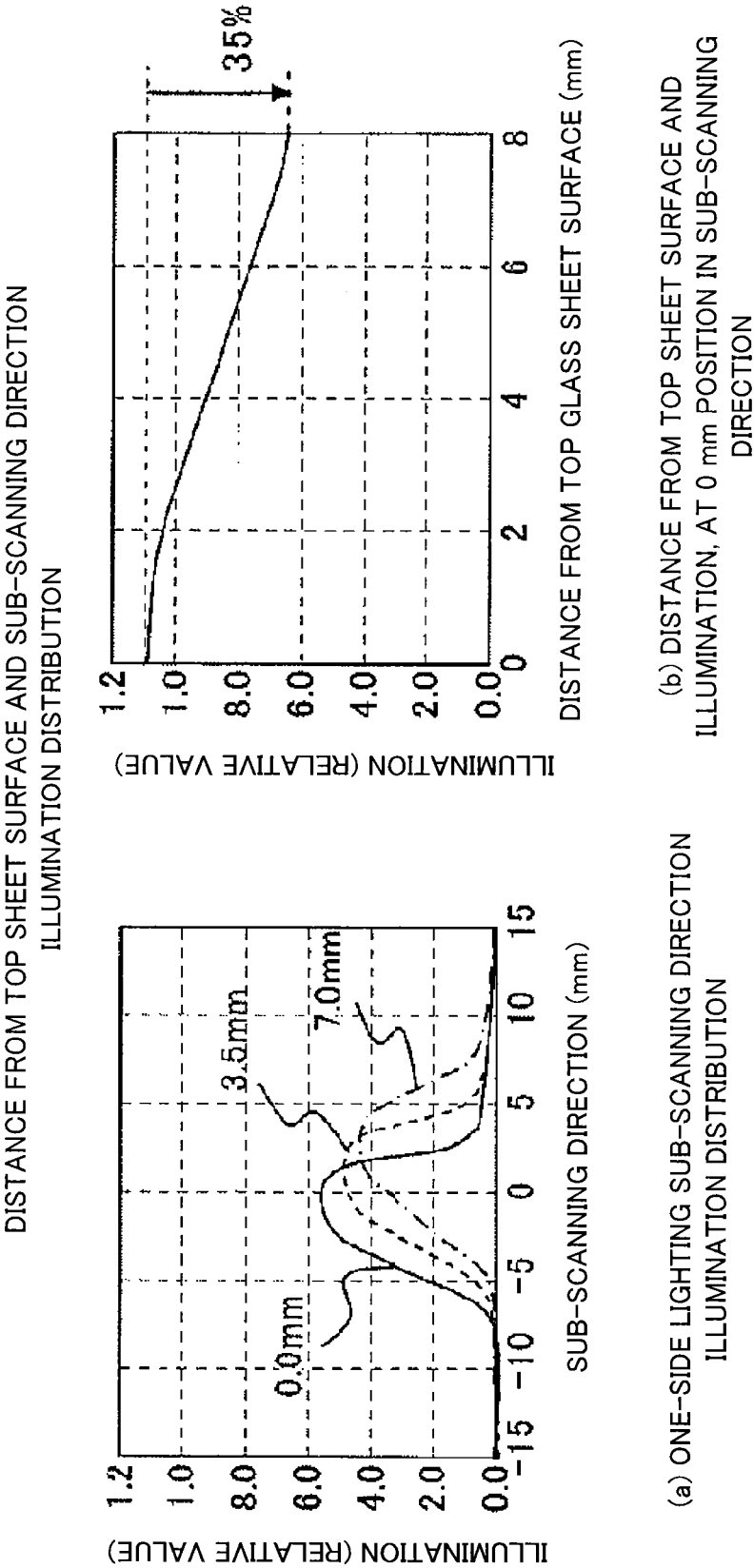


FIG.10

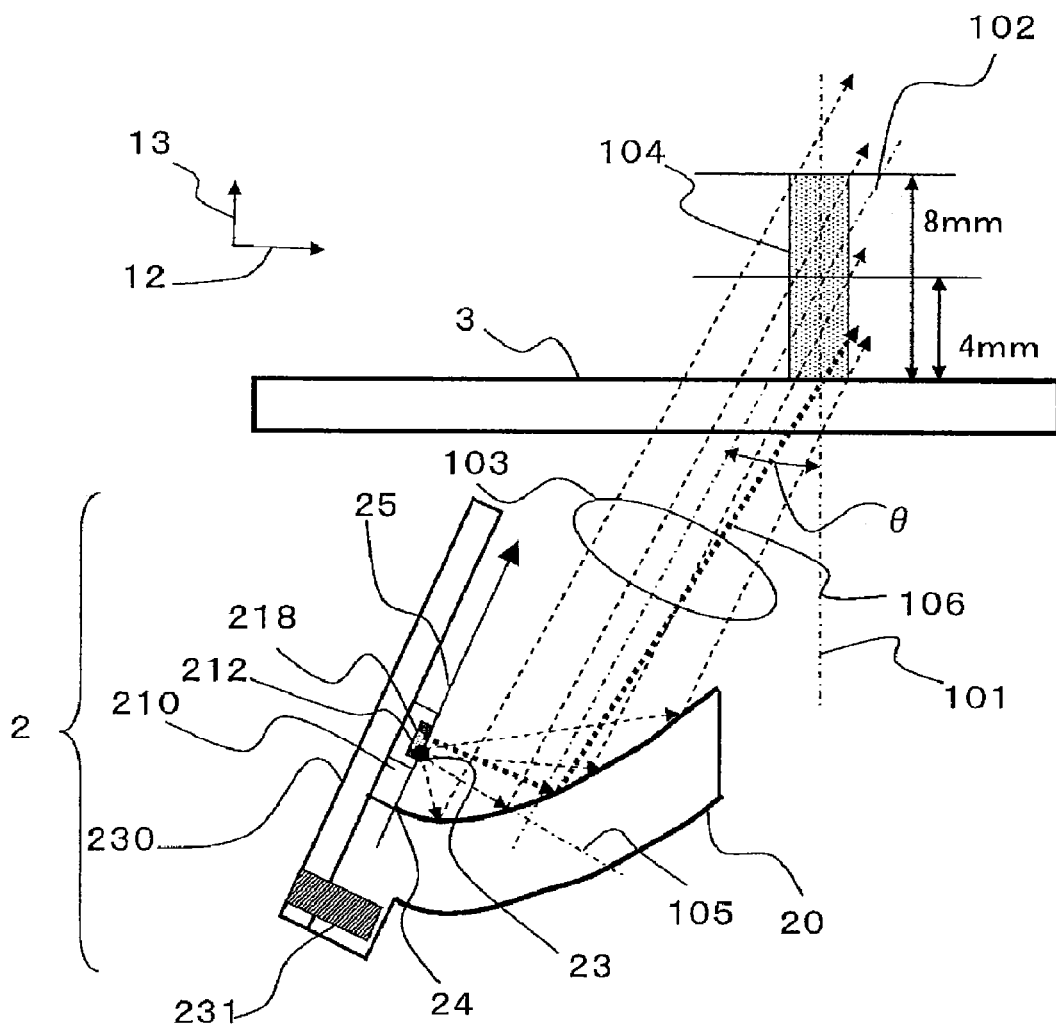


FIG.11

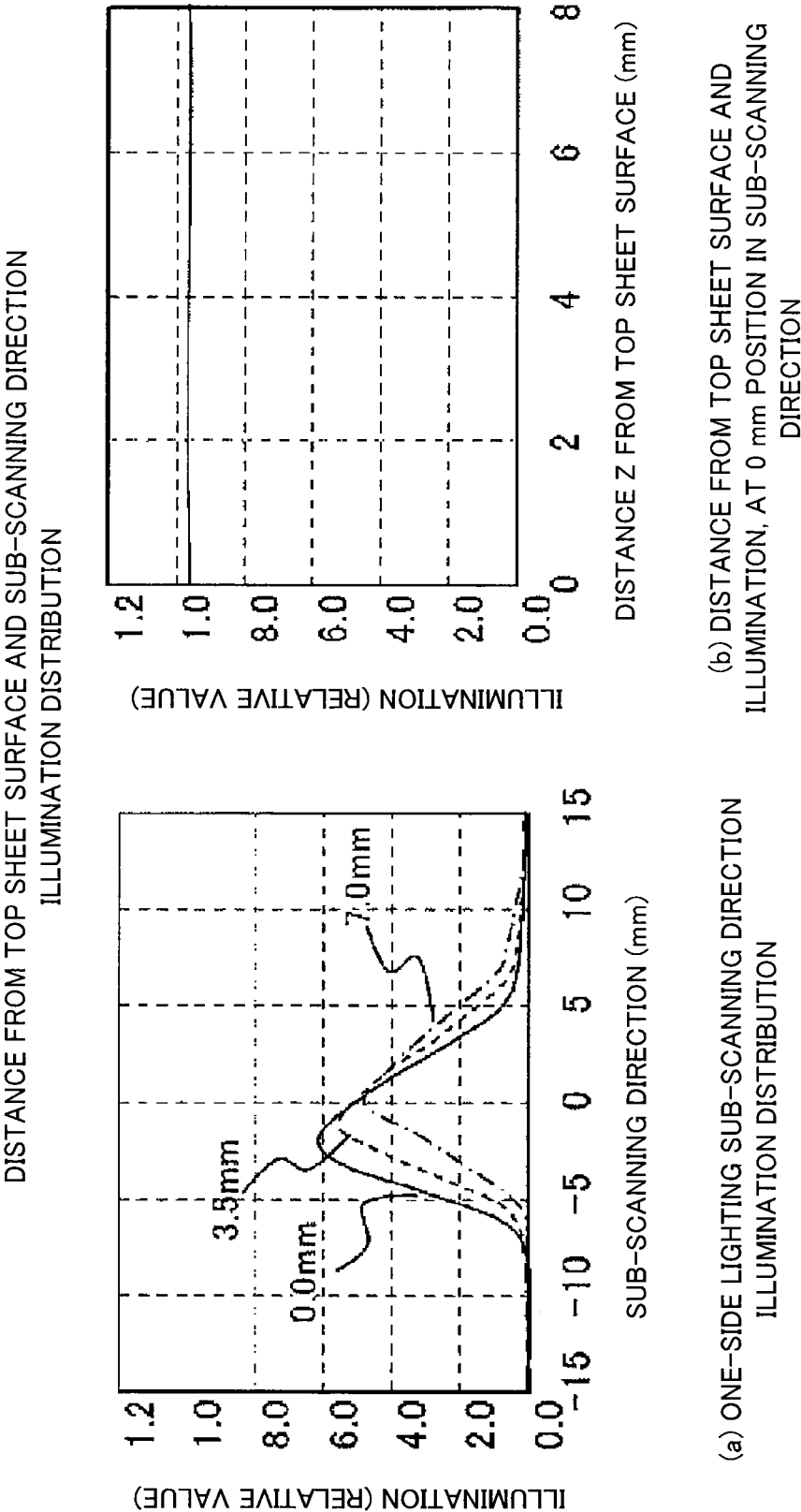


FIG.12

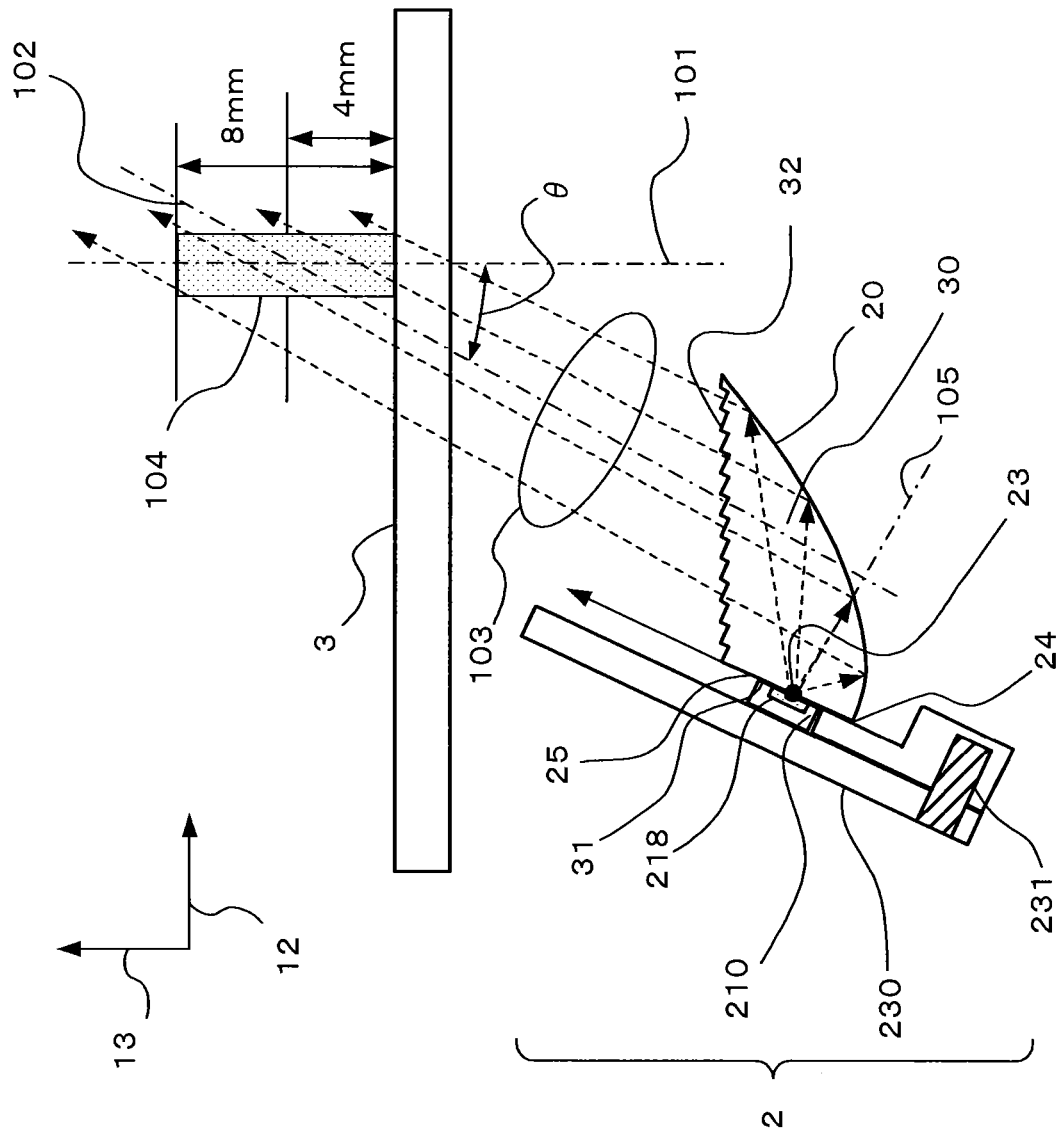


FIG.13

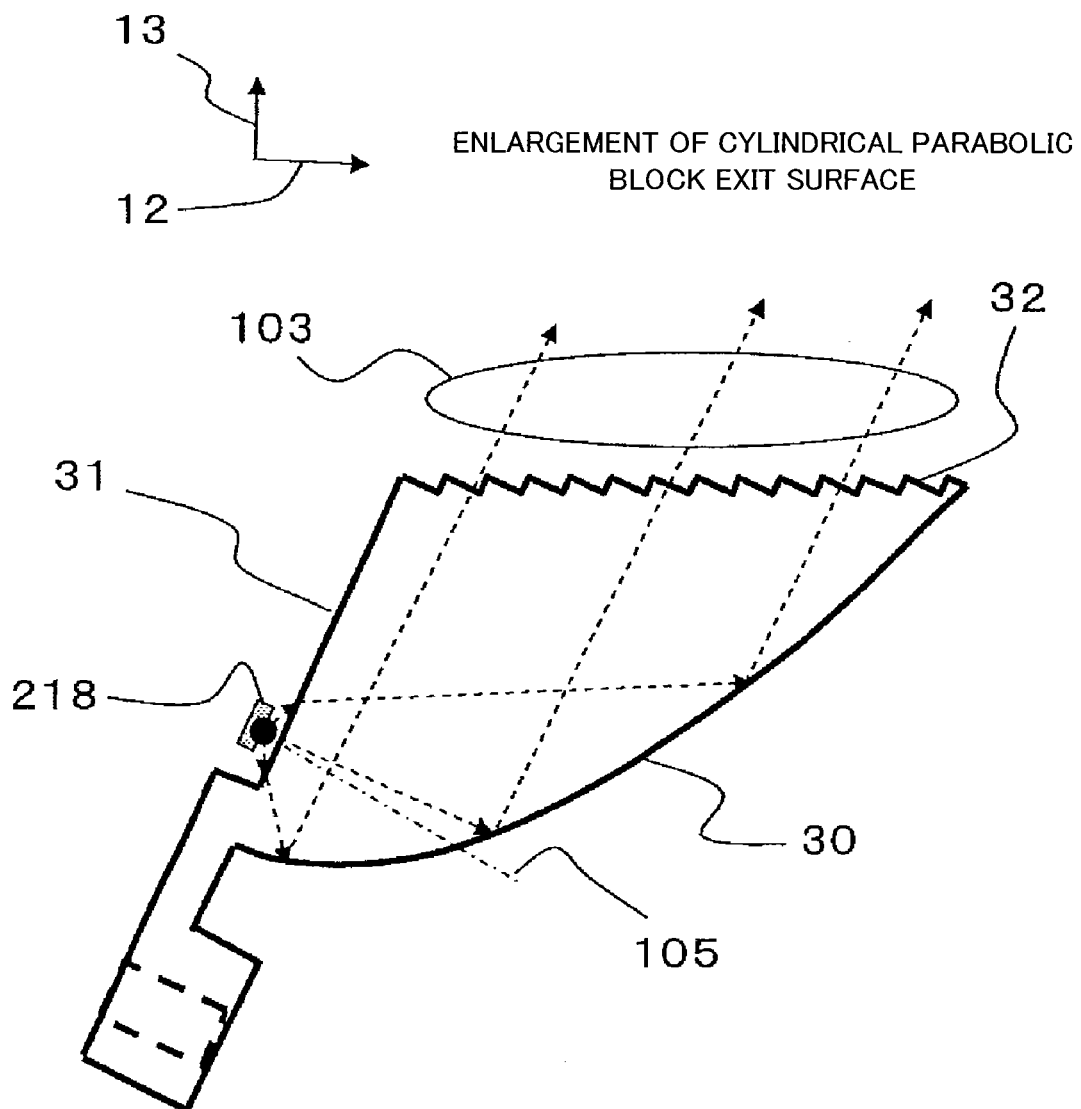


FIG. 14

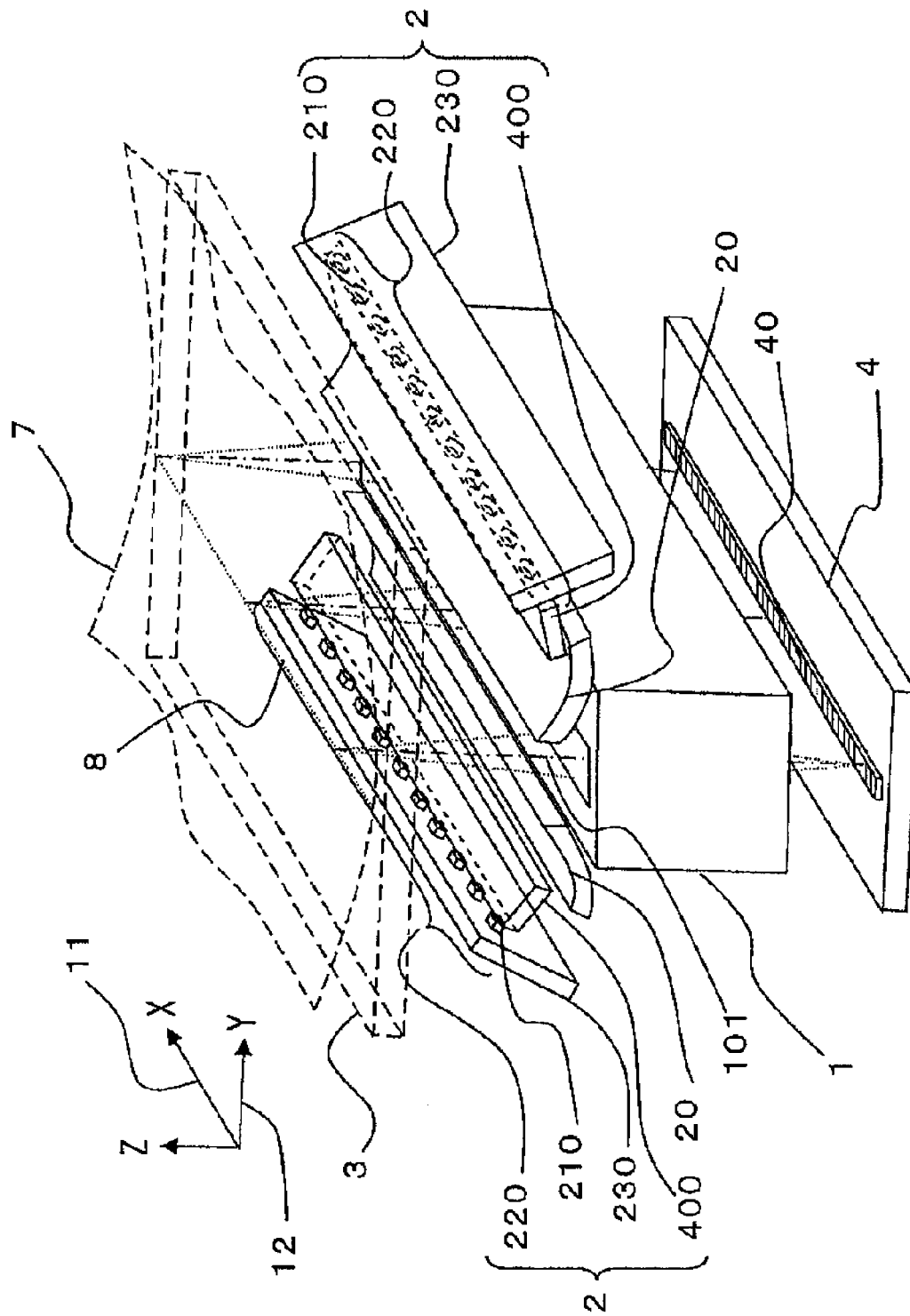


FIG.15

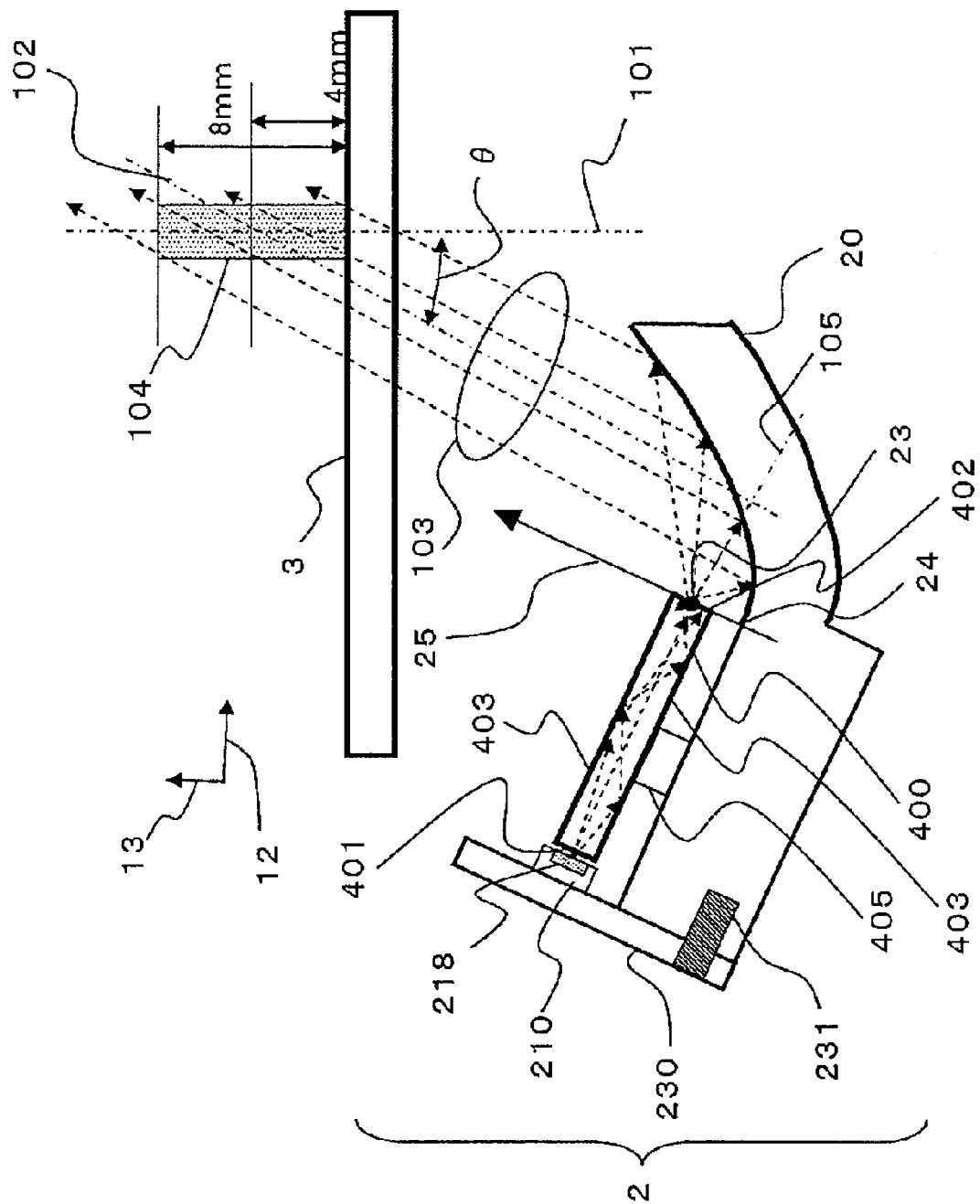


FIG.16

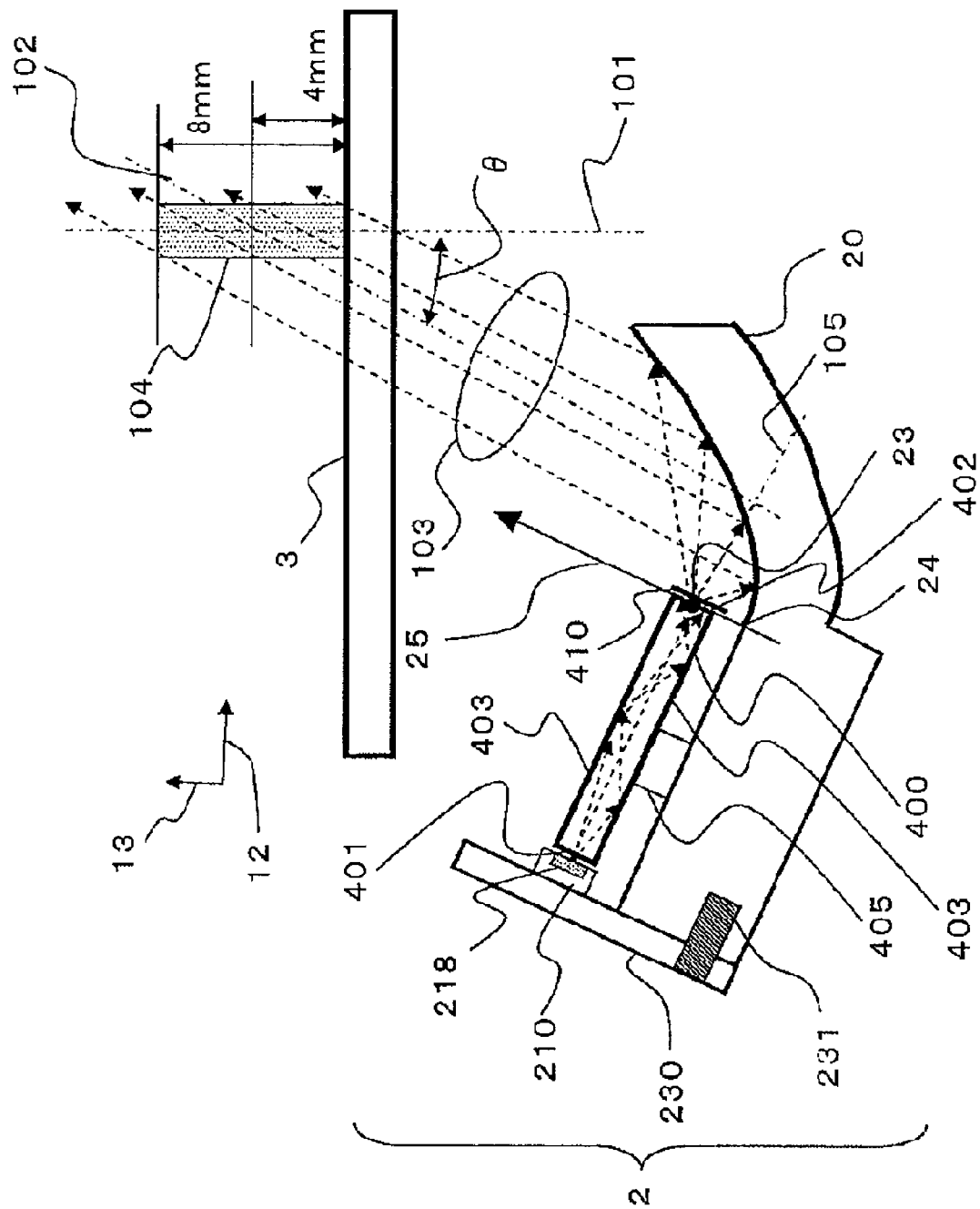


FIG.17

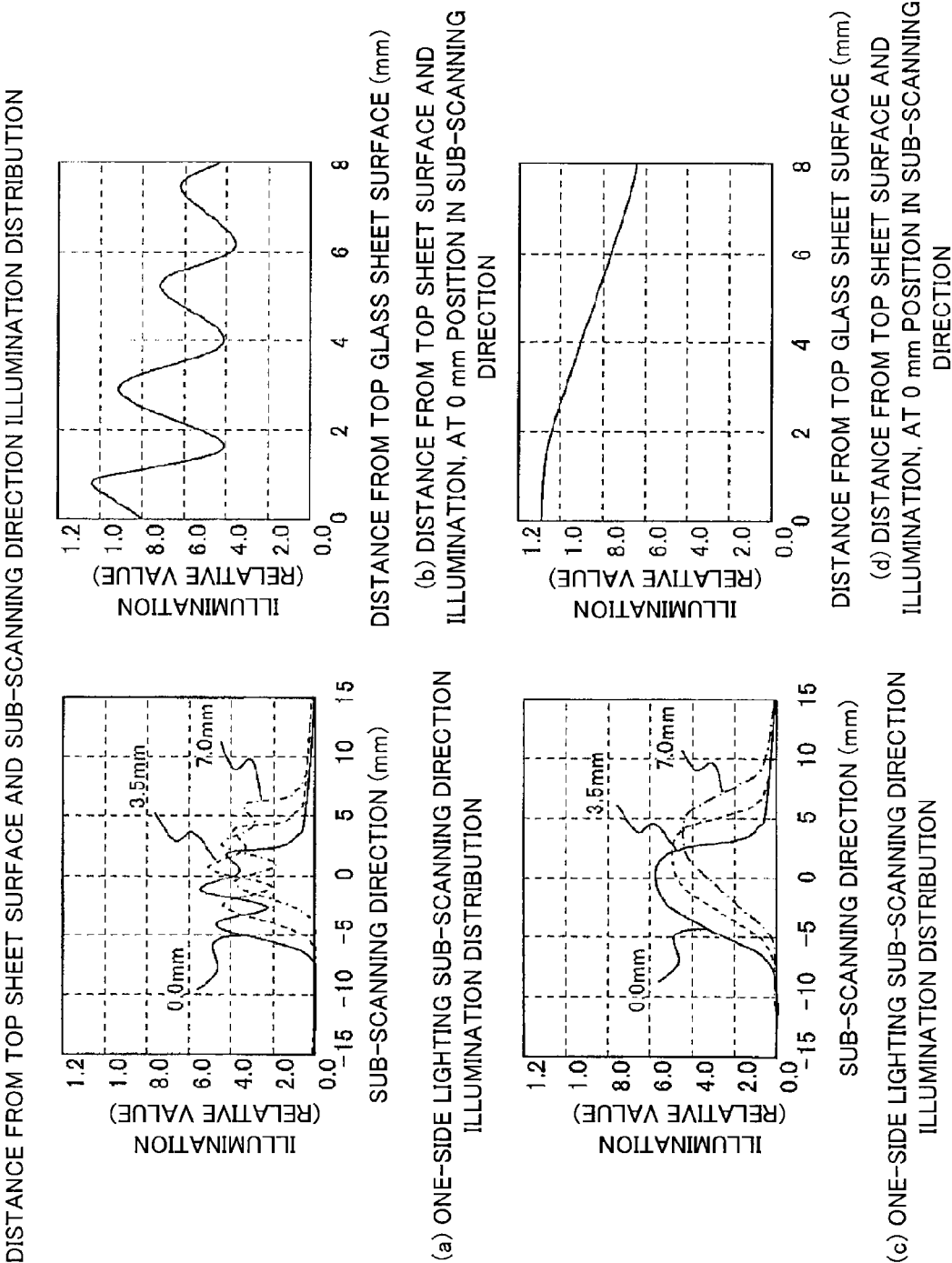


FIG.18

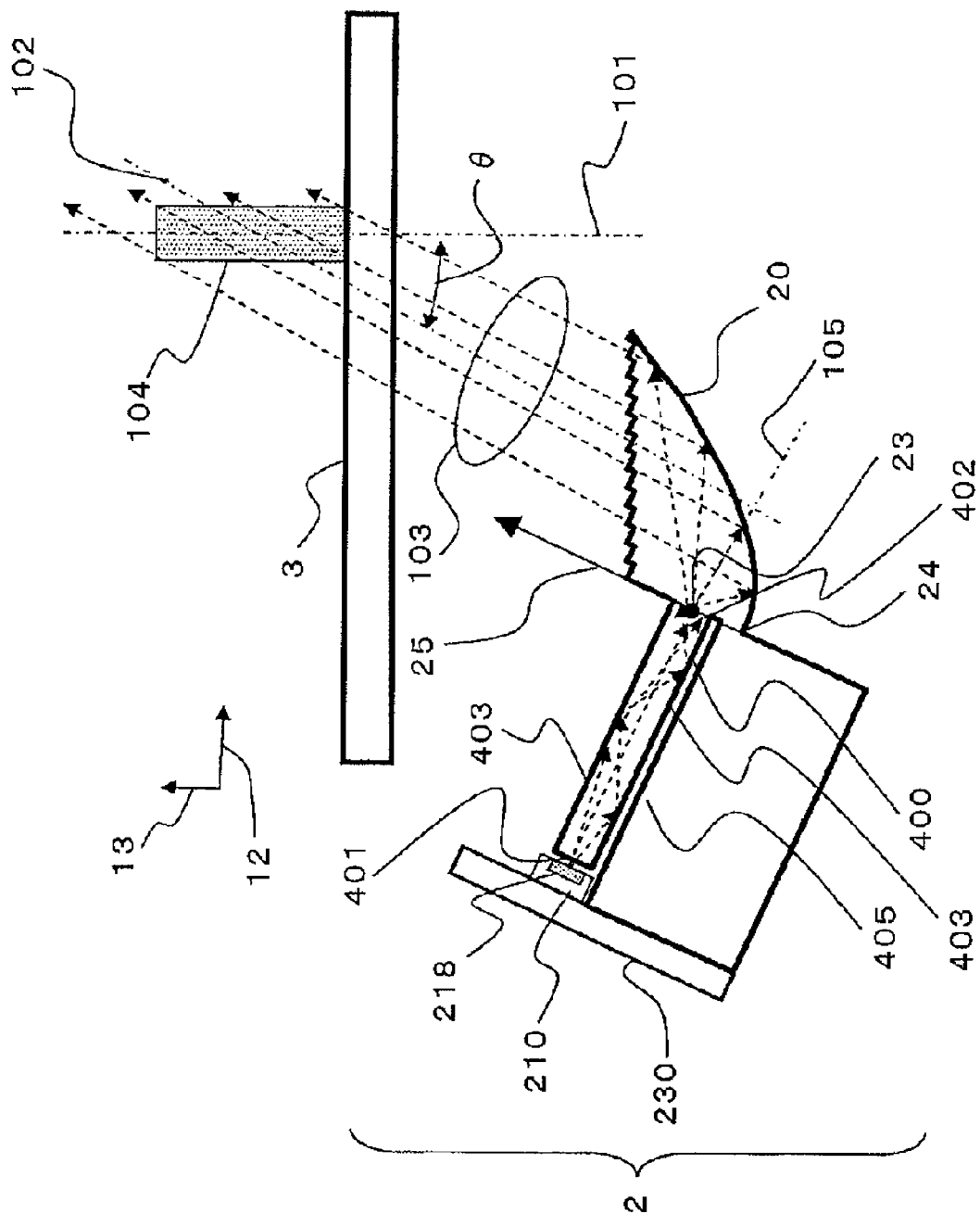


FIG. 19

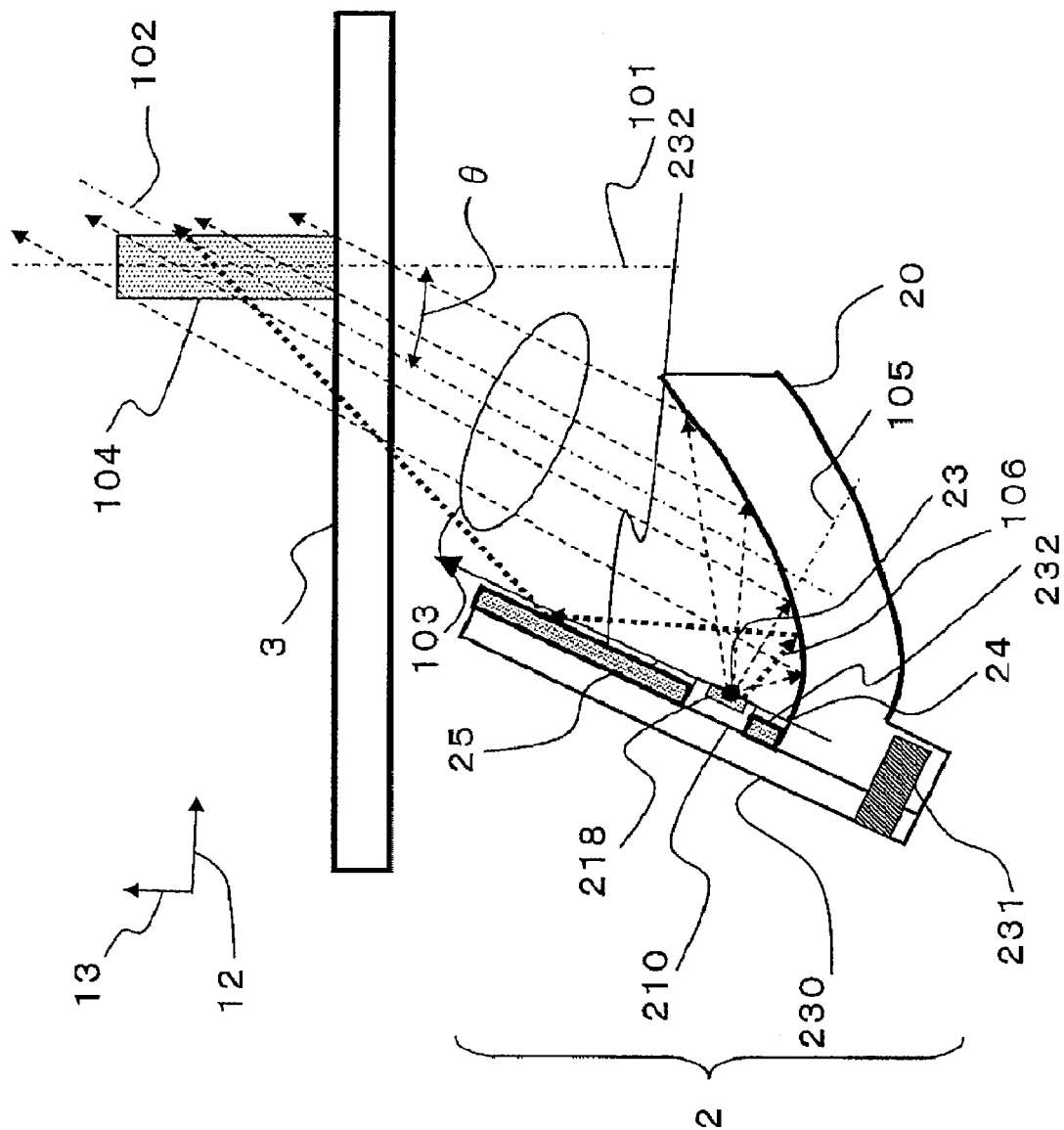


FIG. 20

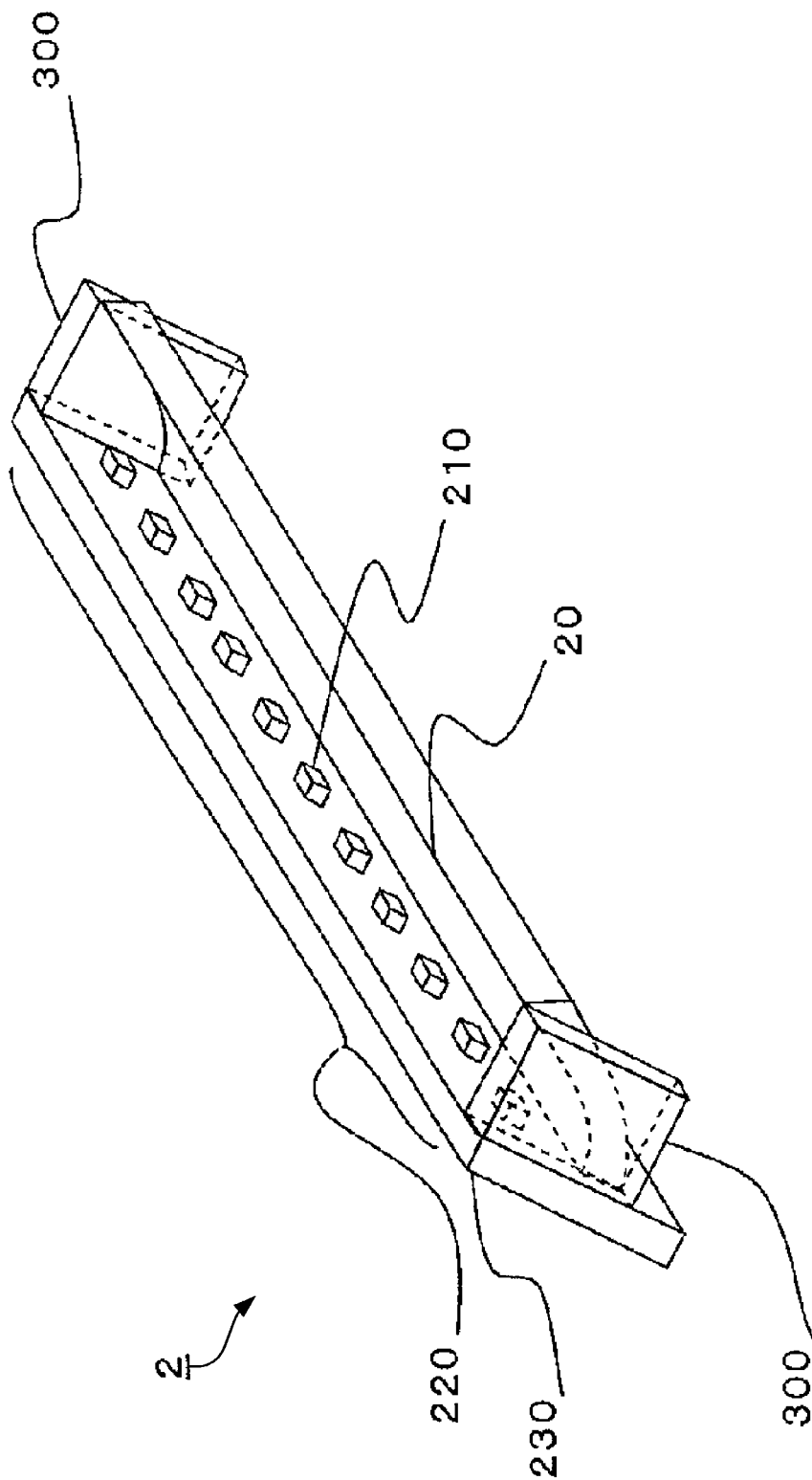


FIG.21

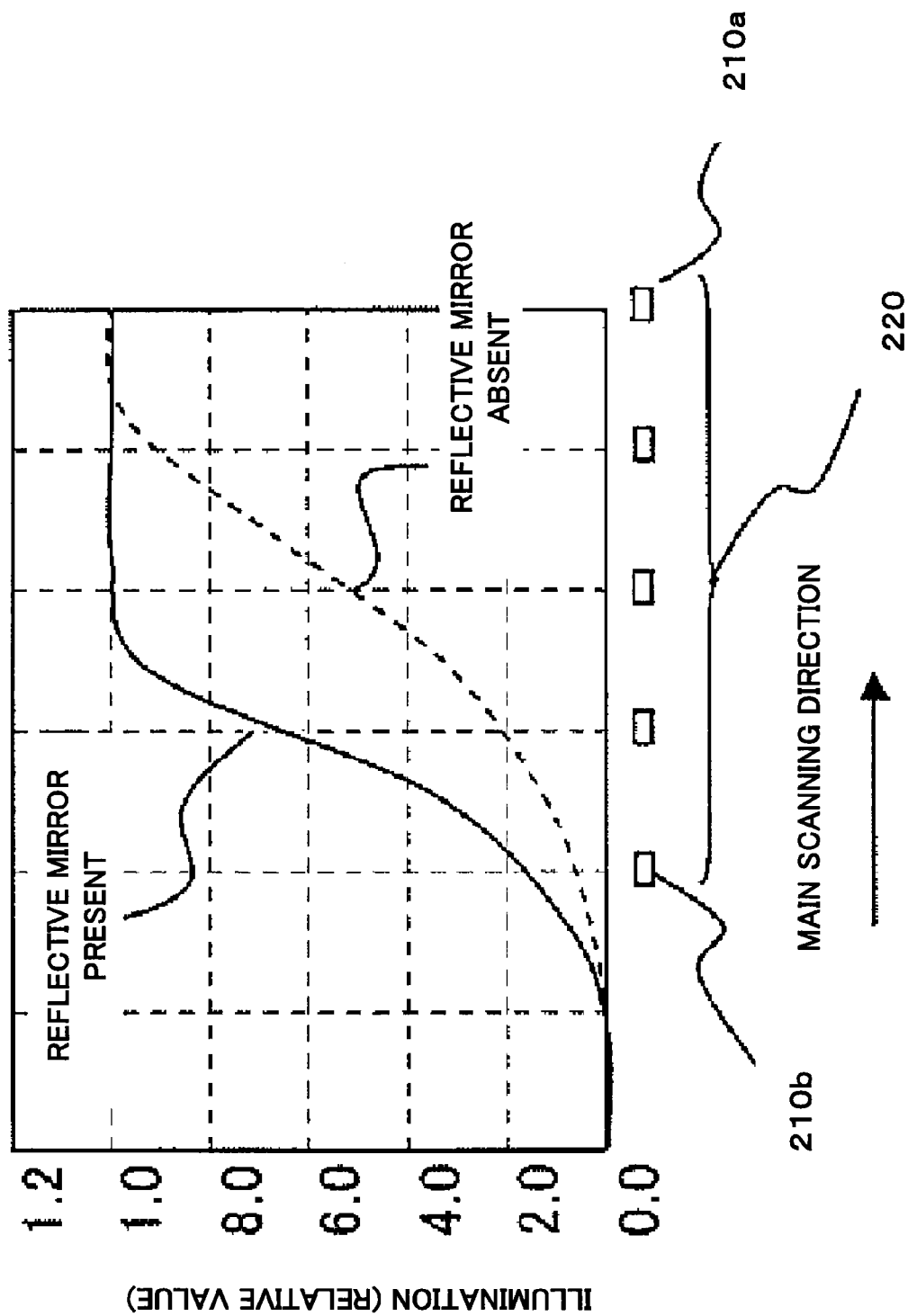


FIG. 22

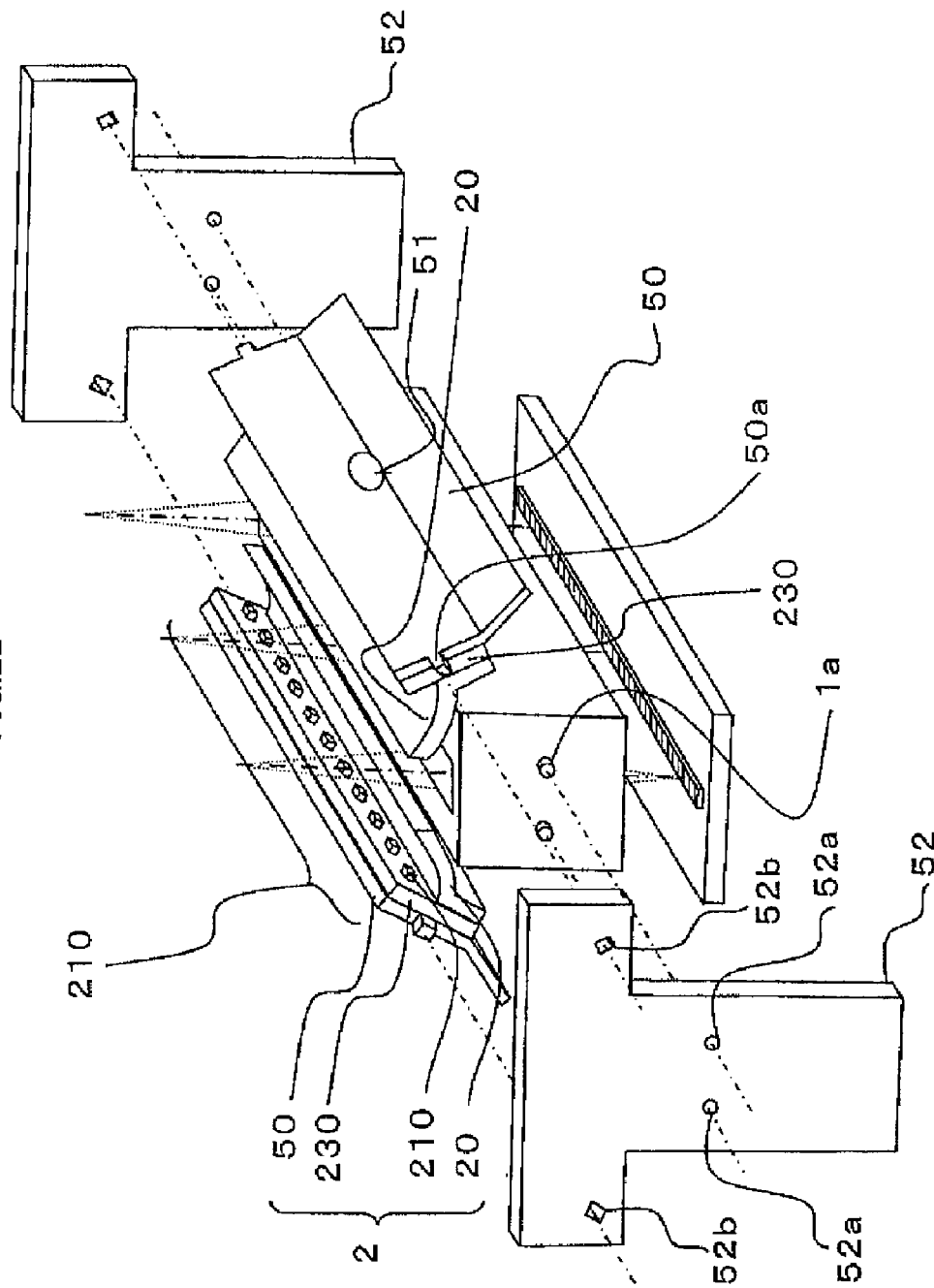


FIG.23

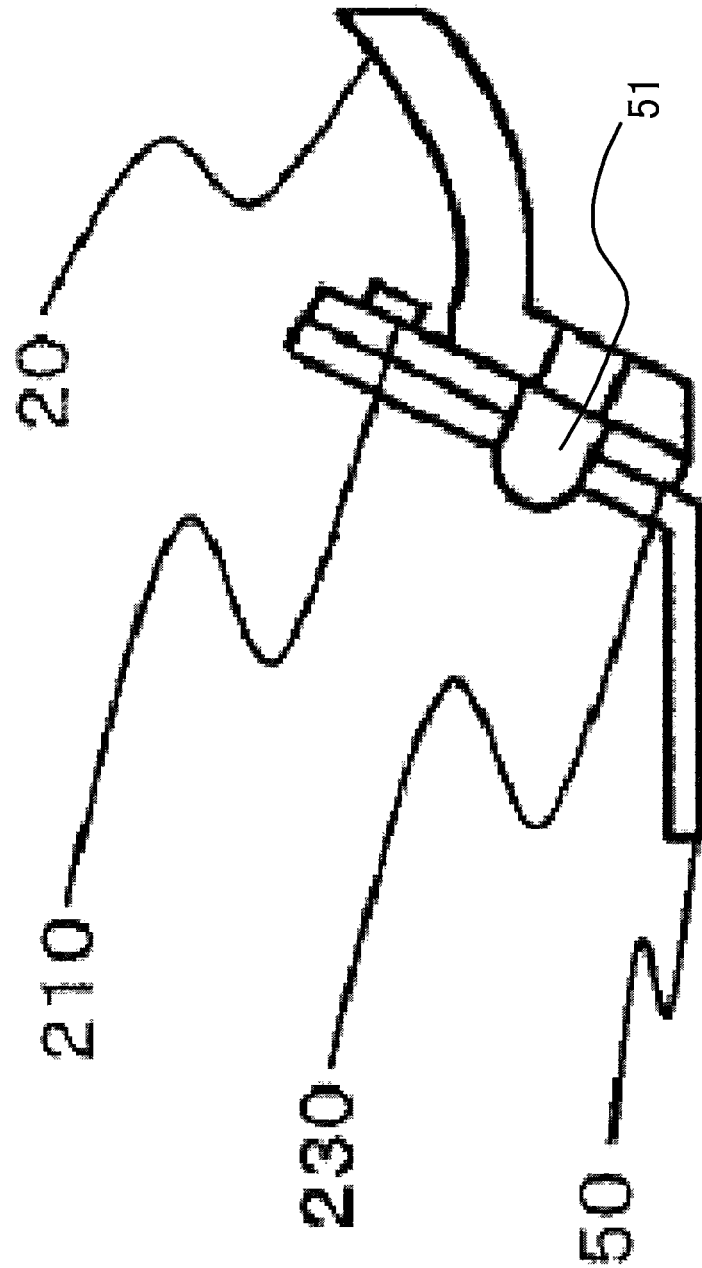


FIG. 24

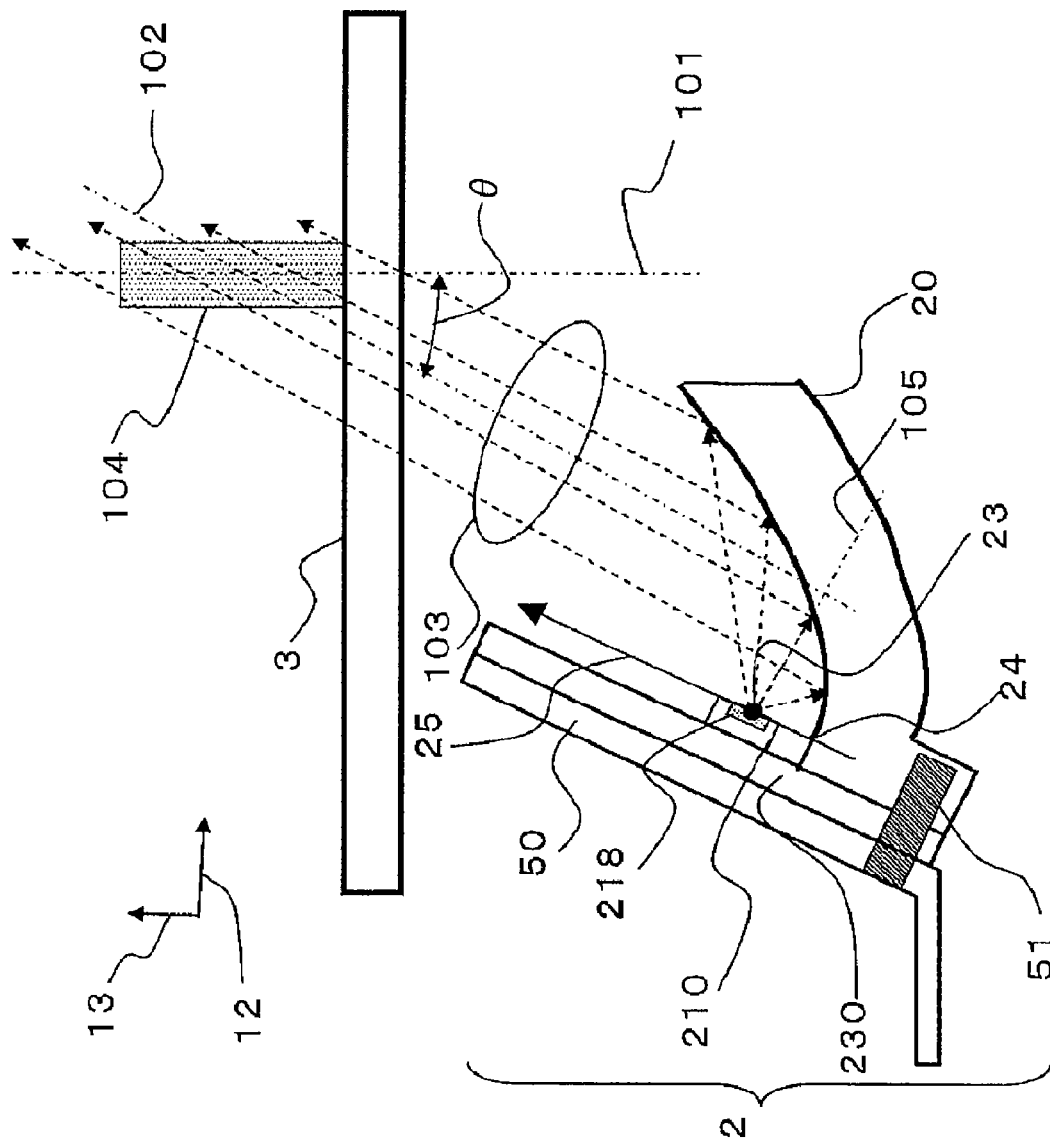
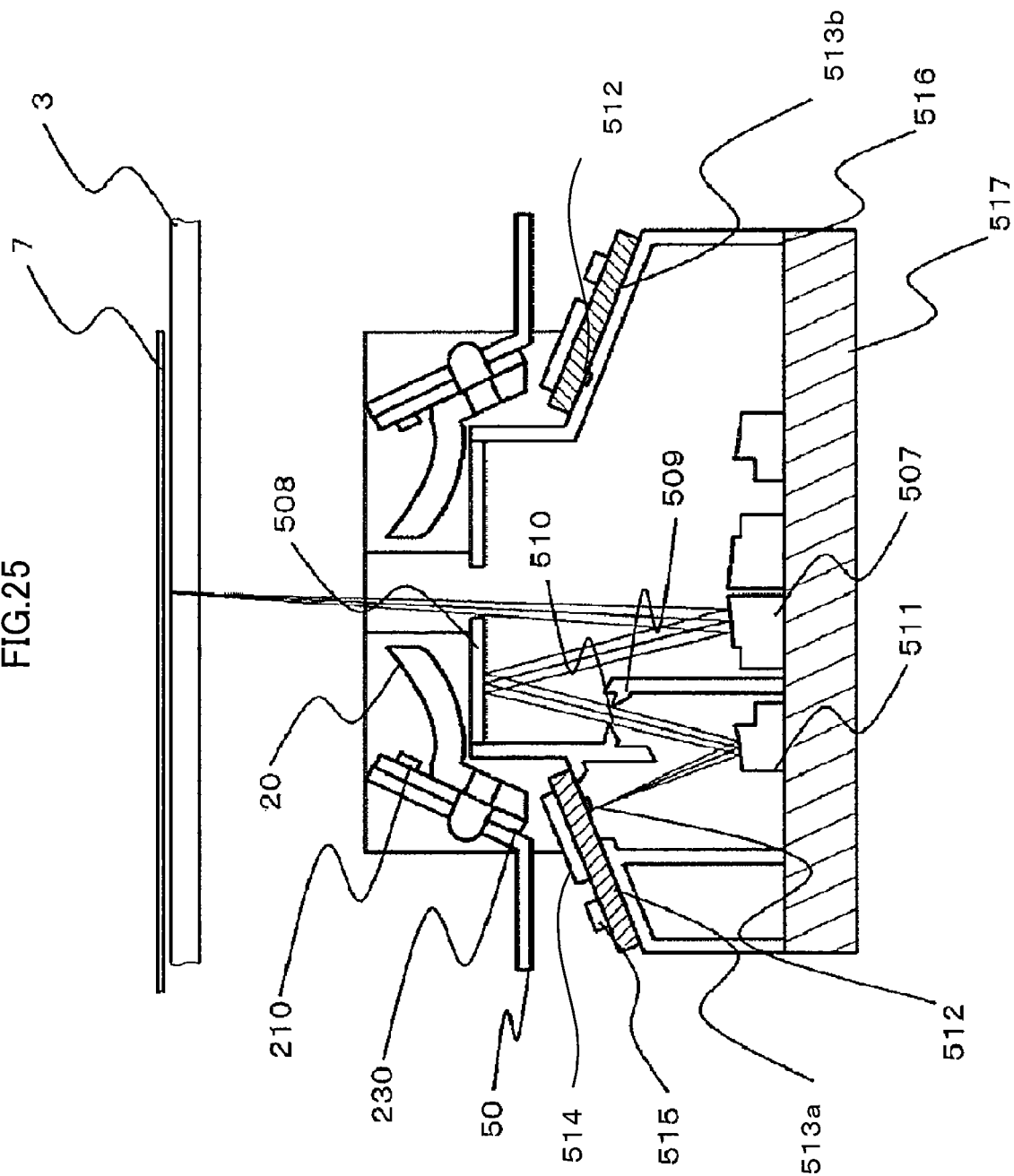


FIG. 25



LIGHTING UNIT AND IMAGE SCANNER USING SAME

TECHNICAL FIELD

The present invention relates to a lighting unit for accomplishing linear lighting of scanned objects, such as printed material or book manuscripts, and to an image scanner using this lighting unit.

BACKGROUND ART

Image scanners are used in copiers, scanners, facsimiles and/or the like. The image scanner is a device for scanning an entire image by scanning the image in a scanning position using a one-dimensional imaging element, and is provided with a lighting unit for accomplishing lighting when reading an original. In the image scanner, it is necessary to scan the image information with good accuracy and at high speed, so a lighting unit composition has been disclosed for uniformly lighting the original with high efficiency. As general expressions, the direction in which a one-dimensional imaging element is arrayed is called the main scanning direction, and the direction of scanning is called the sub-scanning direction. In addition, the direction orthogonal to both the main scanning direction and the sub-scanning direction is called the focal depth direction in a scanning optical system and is called the lighting depth direction in a lighting unit.

The document lighting unit disclosed in Patent Literature 1 is provided with point light sources such as multiple LEDs (Light Emitting Diodes) arranged in the main scanning direction. The direction in which light is emitted from these point light sources is roughly parallel to the normal direction to the document stand on which a document is loaded and is in the opposite direction from the document stand. Light from these point light sources is guided to the document surface as lighting light by multiple reflective surfaces arranged facing the point light sources.

The condensing lighting device disclosed in Patent Literature 2 is provided with a light source positioned at the focal position of a reflective surface on a parabola, and a lens having two types of curvature for condensing light from the light source and light from the reflective surface.

The document lighting device disclosed in Patent Literature 3 is provided with LED elements disposed along the main scanning direction, and a reflective plate surrounding the LED elements. The shape of this reflective plate is a parabolic two-dimensional curve.

Patent Literature 4 discloses the composition of a light guide, lighting unit and image-scanning lighting device capable of realizing lighting with high illumination, large lighting depth and broad lighting width in the sub-scanning direction.

CITATION LIST

Patent Literature

- Patent Literature 1: Unexamined Japanese Patent Application Kokai Publication No. 2010-199875 (FIGS. 1-9)
 Patent Literature 2: Japanese Patent Official Announcement No. H4-15457 (Line 43 of column 3 to line 24 of column 6, FIGS. 1-3)
 Patent Literature 3: Unexamined Japanese Patent Application Kokai Publication No. 2005-234108 (FIGS. 1, 2)
 Patent Literature 4: Unexamined Japanese Patent Application Kokai Publication No. 2009-272215 (FIG. 3)

SUMMARY OF INVENTION

Technical Problem

In the image scanner, it is necessary to have a lighting device with a large lighting depth when utilizing a scanning optical system having a large focal depth enabling clear imaging of images of scanned objects having unevenness on the surface, such as book manuscripts or wrinkled paper money. When scanning documents having unevenness, fluctuations in the brightness of the scanned images occur when there is a brightness distribution in the lighting depth direction.

The document lighting unit disclosed in Patent Literature 1 comprises multiple reflective surfaces, so the angular component of the lighting light rays toward the document surface from the respective reflective surfaces with respect to the document stand has multiple peaks. As a result, it is difficult to achieve lighting with uniform illumination of a document whose distance from the document stand changes, such as a book manuscript and/or the like.

With the lighting device disclosed in Patent Literature 2, it is possible for the lighting light rays to approach parallel light rays as a result of a combination of parabolas and lenses, so lighting with uniform illumination is relatively easy on documents in which the distance from the document stand changes, such as book manuscripts and/or the like. However, the lighting device disclosed in this Patent Literature comprises a parabolic reflective mirror and lenses having two types of curvature, so the size of the optical system becomes large and compactness of the lighting device is difficult to realize, and cost also becomes an issue.

With the document lighting device disclosed in Patent Literature 3, the LED elements are lined up in the main scanning direction, reflective plates surrounding the LED elements are provided and the shape of the reflective plates is a parabolic two-dimensional curve. Consequently it is possible for the lighting light rays to approach parallel light rays, so that lighting with uniform illumination is relatively easy on documents such as book manuscripts and the like whose distance from the document stand changes. However, in order to provide the reflective plates surrounding the LED elements, the optical system becomes large and making the lighting device compact becomes difficult.

In Patent Literature 4, a composition is disclosed in which parallel light rays are produced using a light guide.

It is an objective of the present invention to provide a lighting unit and image scanner that realize with a simple composition high-illumination lighting having large lighting depth.

Solution to Problem

The lighting unit according to the present invention comprises:
 a light source in which light-emitting elements are positioned in an array in a main scanning direction;
 a parabolic mirror that projects light emitted from the light source on an illumination region of an illuminated item; and
 a housing that stores or supports the light source and the parabolic mirror;
 wherein the parabolic mirror forms a shape in which a cylindrical paraboloid having curvature with respect to a sub-scanning direction has been clipped by an axial plane that is perpendicular to the vertex of the cylindrical paraboloid in the main scanning direction; and

3

the light source is positioned so as to include the focal position of the cylindrical paraboloid in the light-emitting region of the light of the light source, the central axis in the light-emitting direction of the light of the light source being perpendicular to the axial plane.

Advantageous Effects of Invention

With this invention, lighting of a document by roughly parallel light rays is possible, so it is possible to efficiently light documents. In addition, changes in the light quantity are small in the lighting depth direction, so it is possible to obtain bright images even when the distance to the document is distant. Furthermore, by positioning this kind of lighting unit on both sides of the optical axis of a scanning optical system, linear lighting having large lighting depth and uniformly strong distribution even in the sub-scanning direction is obtained.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a perspective view showing an image scanner according to a first preferred embodiment of the present invention;

FIG. 2 is a drawing showing a parabolic shape equating to the sub-scanning direction cross-sectional shape of a cylindrical parabolic mirror;

FIG. 3 is a light path diagram of the sub-scanning direction cross-section of the lighting unit according to the first preferred embodiment of the present invention;

FIG. 4 is an example of an sub-scanning direction illumination distribution according to the first preferred embodiment of the present invention;

FIG. 5 is an sub-scanning direction cross-section of a lighting unit according to a second preferred embodiment of the present invention;

FIG. 6 is a structural diagram of a white LED obtaining white light by blending secondary light through yellow fluorescent material with a blue light-emitting diode as the light source, with (a) being a view from the LED light-emission direction along the central axis thereof, and (b) being a cross-sectional view taken along line A-A' in (a) of FIG. 6;

FIG. 7 is an sub-scanning direction cross-sectional view of a lighting unit according to a third preferred embodiment of the present invention;

FIG. 8 is a drawing showing the arrangement direction of an LED array according to the third preferred embodiment of the present invention;

FIG. 9 is an example of the sub-scanning direction illumination distribution according to the third preferred embodiment of the present invention;

FIG. 10 is an sub-scanning direction cross-sectional view of a lighting unit according to a fourth preferred embodiment of the present invention;

FIG. 11 is an example of the sub-scanning direction illumination distribution according to the fourth preferred embodiment of the present invention;

FIG. 12 is a cross-sectional view of a lighting unit according to a fifth preferred embodiment of the present invention;

FIG. 13 is a detailed view of the light rays and a cylindrical parabolic block according to the fifth preferred embodiment of the present invention;

FIG. 14 is a perspective view of an image scanner according to a sixth preferred embodiment of the present invention;

FIG. 15 is a light path diagram of the sub-scanning direction cross-section according to the sixth preferred embodiment of the present invention;

4

FIG. 16 is a light path diagram of the sub-scanning direction cross-section according to a seventh preferred embodiment of the present invention;

FIG. 17 is an example of the sub-scanning direction illumination distribution according to the seventh preferred embodiment of the present invention;

FIG. 18 is a cross-sectional view of a lighting unit according to an eighth preferred embodiment of the present invention;

FIG. 19 is a sub-scanning direction cross-sectional view of a lighting unit according to a ninth preferred embodiment of the present invention;

FIG. 20 is a perspective view of a lighting unit according to a tenth preferred embodiment of the present invention;

FIG. 21 is a drawing showing the illumination distribution of the main scanning direction end according to the tenth preferred embodiment of the present invention;

FIG. 22 is a perspective view of an image scanner according to an eleventh preferred embodiment of the present invention;

FIG. 23 is a sub-scanning direction cross-sectional view of a lighting unit according to the eleventh preferred embodiment of the present invention;

FIG. 24 is a sub-scanning direction cross-sectional view of a lighting unit according to a twelfth preferred embodiment of the present invention; and

FIG. 25 is a sub-scanning direction cross-sectional view of an image scanner according to the twelfth preferred embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

Below, the preferred embodiments of the present invention are described with reference to the drawings. Compositional parts that are the same or similar in each drawing are labeled with the same reference signs.

First Preferred Embodiment

FIG. 1 is a perspective view of an image scanner according to a first preferred embodiment of the present invention. The image scanner comprises a top glass sheet 3, a lighting unit 2, an imaging optical system 1 and the like. The top glass sheet 3 is a transparent glass sheet for supporting a scanned object (illuminated item) such as a document 7 and/or the like. The lighting unit 2 is a unit for accomplishing linear lighting of a surface of the document 7. The imaging optical system 1 is a unit for imaging light from the document 7 in an imaging element 40.

To facilitate understanding, the direction of scanning the document through electrical scanning of the imaging element 40 shall be called the main scanning direction 11, the direction in which the document 7 moves relative to the image scanner shall be called the sub-scanning direction 12 and the direction perpendicular to the main scanning direction 11 and the sub-scanning direction 12 shall be called the depth direction 13. Here, the depth direction 13 is such that the direction in which the document 7 is separated from the top glass sheet 3 is the positive (+) direction.

In this preferred embodiment, a composition is shown such that the image scanner moves and accomplishes document scanning with the document 7 in an anchored state, but conversely, it would be fine to have a composition in which document scanning is accomplished by moving the document 7 with a drum conveyor and/or the like with the image scanner in an anchored state.

5

The imaging optical system **1** is positioned along a light path facing from the document **7** to the imaging element **40**, and comprises a lens array and reduction optical system, and/or the like. The imaging element **40** is mounted on a substrate **4** and is a line sensor constituting a photoelectric conversion circuit for photoelectric conversion and a CMOS (Complementary Metal Oxide Semiconductor), CCD (Charge Coupled Device Image Sensor) and/or the like comprising the driver thereof.

The lighting unit **2** is positioned between the top glass sheet **3** and the imaging optical system **1** and accomplishes linear lighting along a scan line **8** along the x-direction to the surface of the document **7** by shining light onto the document **7** positioned on top of the top glass sheet **3**.

In addition, the lighting unit **2** comprises an LED array **220**, an LED substrate **230** and a cylindrical parabolic mirror **20**. The LED array **220** comprises LED chips **210** that are LED light sources, lined up linearly in the main scanning direction. The LED substrate **230** is a substrate on which the LED array **220** is mounted. The cylindrical parabolic mirror **20** is a cylindrical concave mirror that makes light emitted from the LED array **220** roughly parallel light rays and emits this lighting light toward a scan line **8**.

The cylindrical parabolic mirror **20** has curvature in the sub-scanning direction **12** and has no curvature in the main scanning direction **11**. FIG. **2** shows a parabolic shape equating to the sub-scanning direction cross-sectional shape of the cylindrical parabolic mirror **20**. In FIG. **2**, the tangential direction at the vertex **24** of the parabola, that is to say at $y=0$ and $z=0$, is taken as the y direction and the normal direction is taken as the z direction. The parabola is given by the following equation (Equation 1), where f is the focal length and $y=0$ and $z=f$ is the cylindrical parabola focal position **23**.

[Equation 1]

$$z = \frac{cy^2}{1 + \sqrt{1 + (k/c^2)y^2}} \quad (\text{Equation 1})$$

$$c = 1/R$$

$$f = R/2,$$

$$k = -1$$

In addition, as shown in FIG. **2** the cylindrical parabolic mirror **20** is formed of only a semi-cylindrical parabola $y+$ **21** when the parabola is divided at $y=0$ and the $y+$ direction is considered a semi-cylindrical parabola $y+$ **21** and the $y-$ direction is considered a semi-cylindrical parabola $y-$ **22**. Here, the z axis is called the axis of the parabola, and the surface orthogonal to the y axis and including the axis of the parabola is called the cylindrical parabola axial plane **25**.

FIG. **3** shows a light path diagram of the sub-scanning direction cross-section according to the first preferred embodiment of the present invention. In FIG. **3**, the case where the lighting unit **2** is positioned to one side of an imaging optical axis **101** is shown. In order to avoid interference with the imaging optical axis **101**, the lighting unit **2** needs to be such that in general a lighting optical axis **102** is inclined from the imaging optical axis **101**. Furthermore, because there could be assembly errors in the lighting unit **2** and the imaging optical system **1**, a lighting region **104** is a region widening in the sub-scanning direction **12**, and moreover, in order to cope with book manuscripts and wrinkles in and floating of the document, when the focal depth becomes larger, the lighting region **104** broadens in the depth direction **13** as well. Consequently, in the lighting unit **2** there is a

6

certain degree of width in the sub-scanning direction **12**, and uniform, substantially parallel light rays are necessary. Furthermore, when a certain degree of width in the sub-scanning direction **12** is secured, illumination drops and the scanning speed becomes slower, so it is necessary to improve the usage efficiency of the LED light.

Hence, with the first preferred embodiment of the present invention, an LED light-emission region **218** is positioned at a position including the cylindrical parabola focal position **23**. Lighting light rays **103** emitted from the cylindrical parabola focal position **23** are reflected by the cylindrical parabolic mirror **20**, become parallel light rays, pass through the top glass sheet **3** and reach the lighting region **104**. A central axis **105** in the light-emission direction of the LED is positioned in a direction perpendicular to the cylindrical parabola axial plane **25**. Because the LED's light emission intensity is at a maximum on the central axis **105** of the light-emission direction of the LED, it is possible for LED light to be efficiently incident on the cylindrical parabolic mirror **20**.

Accordingly, with this composition, lighting light close to parallel light is efficiently obtainable, so it is possible to efficiently light the document **7** and it is also possible to reduce changes in light amounts in the lighting depth direction. Consequently, even when the distance between the document **7** and the top glass sheet **3** is distant, it is possible to obtain a bright image.

FIG. **4** shows an sub-scanning direction illumination distribution according to the first preferred embodiment of the present invention. FIG. **4(a)** shows the sub-scanning direction illumination distribution when the lighting unit **2** is positioned to one side of the imaging optical axis **101**, as shown in FIG. **3**. In lighting by only the lighting unit on one side, the sub-scanning direction illumination distribution is an asymmetrical distribution with respect to the sub-scanning direction **12**, and when the imaging optical axis **101** and the lighting optical axis **101** are shifted due to assembly errors and/or the like, illumination on the imaging optical axis **101** changes. In contrast, FIG. **4(b)** shows the sub-scanning direction illumination distribution when the lighting unit **2** is positioned on both sides of the imaging optical axis **102**. The sub-scanning direction illumination distribution becomes the sum of the lighting light from the lighting unit **2** on both sides and thus is a symmetrical illumination distribution with respect to the sub-scanning direction **12**.

Accordingly, with this composition it is possible to change illumination in the depth direction by setting the intersection position of optical axes of lighting units on both sides.

It would also be fine to set the illumination distribution of lighting units on both sides symmetrical with respect to the imaging optical axis **101**.

For example, when the size of the illumination region **104** is taken to be 1 mm in the sub-scanning direction and 8 mm in the depth direction, and when the inclination θ of the lighting optical axis **102** to the imaging optical axis **101** is 20° - 30° , the focal length f of the cylindrical parabolic mirror **20** is appropriately around 10 mm to 20 mm.

Second Preferred Embodiment

FIG. **5** is an sub-scanning direction cross-sectional view of a lighting unit according to a second preferred embodiment of the present invention. In the second preferred embodiment of the present invention, the cylindrical parabolic mirror **20** and the LED substrate **230** are positioned using a position-determining pin **231**. Through this it is possible to accurately align the positional relationship of the cylindrical parabolic mirror

7

20 and the LED light-emission region 218. As a result, the parallelism of the lighting light is maintained, it is possible to control scattering in the lighting direction and it is possible to reduce scattering of brightness in scanning.

Third Preferred Embodiment

FIG. 6 is a structural diagram of a white LED obtaining white light by blending secondary light from yellow fluorescent material, with a blue light-emitting diode as the light source. The white LED is such that there are depressions in an LED package 211, a blue light-emitting diode 212 is mounted and a yellow fluorescent material 213 is loaded so as to fill the surrounding depressions. A portion of the light emitted from the blue light-emitting diode 212 is emitted to the outside of the LED package 211 without change and becomes blue light comprising white light. In addition, the other portion of the light emitted from the blue light-emitting diode 212 is absorbed by the yellow fluorescent material and the yellow fluorescent material emits light in the region from green to red. This becomes green to red light that comprises white light. Accordingly, the blue light-emission region becomes the region of the blue light-emitting diode 212 and the green to red light-emission region becomes the entire yellow fluorescent material region. That is to say, the blue light and the green to red light have different light-emission regions.

In order to produce parallel light rays with less divergence using the cylindrical parabolic mirror 20, it would be well to cause the center of the light-emission region to match the cylindrical parabola focal position 23. However, when the light-emission regions of blue light and green to red light differ as described above, it is necessary to change the cylindrical parabola focal position 23 depending on wavelength, but realizing this kind of composition is difficult.

On the other hand, in observation by the inventors, it was learned that there is a yellow fluorescent material strong light-emission region surrounding the blue light-emitting diode 212. Accordingly, it is fine to think of the green to red light-emission region as being around the blue light-emitting diode 212, and in order to efficiently make light of all wavelengths into parallel light rays, the conclusion was reached that it would be well to make the light-emission region of the blue light-emitting diode 212 the standard.

FIG. 7 is a sub-scanning direction cross-sectional view of a lighting unit according to the third preferred embodiment of the present invention. When the LED chip shown in FIG. 6 is used, it is necessary to shine light having a broad illumination distribution in the sub-scanning direction 12 in the lighting region 104 in order to increase the lighting depth. Consequently, it is fine to use a light source with a broad light-emission region width, and it is fine for the direction in which LED chips 210 are arrayed in the LED array 220 to be such that the blue light-emitting diode long axis 215 matches the cylindrical parabolic mirror axial plane direction, as shown in FIG. 8.

FIG. 9 is an example of computation of the sub-scanning direction illumination distribution on the top glass sheet 3 when the center of the blue light-emitting diode 212 is caused to match the cylindrical parabolic mirror focal position 23. FIG. 9(a) shows the sub-scanning direction distribution, while FIG. 9(b) shows the illumination change in the depth direction when the sub-scanning direction is at the center of the lighting region. By causing the blue light-emitting diode long axis 215 to match the cylindrical parabolic mirror axial plane direction, the illumination peak in the sub-scanning direction becomes relatively flat and the lighting width in the sub-scanning direction is widened. At this time, the lighting

8

illumination 8 mm above the top glass sheet is reduced around 35% compared to the lighting illumination on (0 mm above) the top glass sheet.

With this kind of composition, it is possible to reduce changes in the depth direction of the sub-scanning direction illumination distribution between the blue light and the green to red light. As a result, it is possible to control color spotting.

Fourth Preferred Embodiment

FIG. 10 is a sub-scanning direction cross-sectional view of a lighting unit according to a fourth preferred embodiment of the present invention. Compared to the above-described third preferred embodiment, the fourth preferred embodiment has a composition that further controls lowering of the lighting illumination in the lighting depth direction. In FIG. 10, the composition is such that the cylindrical parabolic mirror focal position 23 is caused to match the side of blue light-emitting diode 212 on the cylindrical parabolic mirror vertex 24 side.

With this kind of composition, the light rays emitted from the side of the light-emitting diode 212 on the cylindrical parabolic mirror vertex 24 side are turned into parallel light rays by the cylindrical parabolic mirror 20 and are guided to the lighting region 104. On the other hand, light rays emitted from the side of the blue light-emitting diode 212 on the opposite side of the cylindrical parabolic mirror vertex 24 become light rays 106 inclined in the sub-scanning direction from the lighting optical axis 102 and are guided to the lighting region 104. As a result, the lighting distribution in the sub-scanning direction is such that the slope on the + side in the sub-scanning direction becomes gentle, as shown in FIG. 11(a).

Hence, the farther from the top glass sheet 3 in the depth direction, the more the peak illumination position in the sub-scanning direction distribution moves to the sub-scanning direction positive (+) direction, following the lighting optical axis angle θ . Consequently, by appropriately setting the position of the lighting unit 2 and the lighting optical axis angle θ , it is possible to cause each position in the depth direction on the imaging optical axis 101, as shown in FIG. 11(a), and illumination at 0 mm, 4 mm and 8 mm in FIG. 11(a), to match. As a result, it is possible to make the lighting illumination at 8 mm above the top glass sheet to be virtually equal compared to the lighting illumination on (0 mm above) the top glass sheet, as shown in FIG. 11(b).

Accordingly, with this composition it is possible to asymmetrically dim the lighting illumination depth in the sub-scanning direction, so it is possible to further reduce the amount of change in the lighting illumination distribution in the sub-scanning direction of the depth direction of the blue light and the green to red light caused by the fact that the light-emission regions differ.

Fifth Preferred Embodiment

FIG. 12 is a cross-sectional view of a lighting unit according to a fifth preferred embodiment of the present invention. The lighting unit according to this fifth preferred embodiment of the present invention uses as the cylindrical parabolic mirror a cylindrical parabolic block 30 that is a real block formed of transparent resin. Similar to the first preferred embodiment, the cylindrical parabola focal position 23 is in the LED light-emission region 218. Light discharged from the LED chips 210 is incident from the cylindrical parabolic block incident surface 31 to the cylindrical parabolic block 30 toward the cylindrical parabolic mirror 20, is reflected by the

inner surface of the cylindrical parabolic mirror **20** and is shined on the lighting region **104** from the cylindrical parabolic block exit surface **32** as substantially parallel light rays.

FIG. **13** shows a detailed view of the light rays and the cylindrical parabolic block **30**. Consider the case in which the cylindrical parabolic block incident surface **31** is parallel to the cylindrical parabola axial plane **25** and is positioned orthogonal to the central axis **105** of the LED chips **210** in the light-emission direction. The cylindrical parabolic block **30** is formed of resin and/or the like and thus has a refractive index higher than air. Consequently, light emitted from the LED light-emission region **218** when incident on the cylindrical parabolic block **30** is refracted in the direction of the central axis **105** in the light-emission direction of the LED chips **210** by the cylindrical parabolic block incident surface **31**. As a result, the divergence angle of the cylindrical parabolic block **30** becomes narrower, arriving at the cylindrical parabolic mirror **20**.

Accordingly, more light rays reach the cylindrical parabolic mirror **20** than the cylindrical parabolic mirror **20** positioned in the air shown in FIG. **5** and are reflected as substantially parallel light rays, making it possible to more efficiently use LED light. Furthermore, the cylindrical parabolic block exit surface **32**, as shown in FIG. **13**, is formed in a prism shape comprising a surface substantially orthogonal to and a surface substantially parallel to the light rays reflected by the cylindrical parabolic mirror **20**, so it is possible to emit light rays without changing the angle of light rays reflected by the cylindrical parabolic mirror **20**.

Sixth Preferred Embodiment

FIG. **14** is a perspective view of an image scanner according to a sixth preferred embodiment of the present invention. The image scanner comprises a top glass sheet **3**, a lighting unit **2** and an imaging optical system **1**. The top glass sheet **3** is a transparent glass plate for supporting a scanned object, such as a document **7** and the like. The lighting unit **2** is a unit for accomplishing linear lighting of the surface of the document **7**. The imaging optical system **1** is a unit for imaging light from the document **7** onto an imaging element **40**.

In this preferred embodiment, the lighting unit **2** comprises an LED array **220**, an LED substrate **230**, a light guide plate **400** and a cylindrical parabolic mirror **20**. The LED array **220** comprises LED chips **210** that are LED light sources lined up linearly in the main scanning direction. The LED substrate **230** is a substrate on which LED array **220** is mounted. The light guide plate **400** guides light emitted from the LED array **220** to the cylindrical parabolic mirror **20**. The cylindrical parabolic mirror **20** is a cylindrical concave mirror for turning light emitted from the light guide plate **400**, that is to say light emitted from the LED chips **210** via the light guide plate **400**, into substantially parallel light rays and shining the lighting light on a scan line **8**.

FIG. **15** is a light path diagram of the sub-scanning direction cross-section according to the sixth preferred embodiment of the present invention. The LED light-emission region **218** is positioned adjacent to the light guide plate incident surface **40** that is one side end of the light guide plate **400**. The light guide plate **400** is a parallel planar substrate composed of plate-shaped transparent material extending in the main scanning direction, and the surface opposite the surface adjacent to the LED chips **210**, in other words the light guide exit surface **402**, is positioned at a position including the cylindrical parabola focal position **23**. The lighting light rays **103** emitted from the light guide plate exit surface **402** near the cylindrical parabola focal position **23** are reflected by the

cylindrical parabolic mirror **20**, pass through the top glass sheet **3** as substantially parallel light rays and reach the lighting region **104**. Here, it is necessary for the lighting unit **2** to be such that in general the lighting optical axis **102** is inclined from the imaging optical axis **101**, in order to prevent interference with the imaging optical axis **101**. Furthermore, because of assembly errors in the lighting unit **2** and the imaging optical system **1**, the lighting region **104** is a region spreading out in the sub-scanning direction **12**, and moreover in order to cope with book manuscripts and wrinkles in and floating of the document, when the focal depth becomes larger, the lighting region **104** widens in the depth direction **13** also. Consequently, with the lighting unit **2** there is a certain degree of width in the sub-scanning direction **12** and uniform, substantially parallel light rays are necessary.

Here, with the lighting unit **2** in the sixth preferred embodiment it is possible to set the lighting width in the sub-scanning direction **12** by combining the width of the light guide plate exit surface **402** in the cylindrical parabolic mirror axial plane direction in addition to the inclination θ of the imaging optical axis **101** to the lighting optical axis **102** and the focal length of the cylindrical parabolic mirror **20**. In the first through fifth preferred embodiments, the size of the light-emission region of the LED was directly related to the lighting width in the sub-scanning direction **12**, but in this sixth preferred embodiment, it is possible to set the lighting width in the sub-scanning direction without relation to the size of the light-emission region of the LED. That is to say, in a white LED obtaining white light by blending secondary light from a yellow fluorescent material having a blue light-emitting diode as a light source, even when the light-emission regions differ between the blue light and the green to red light, by using the light guide plate **400** it is possible to accomplish uniformity in directionality and it is possible to make the lighting widths in the sub-scanning direction match. Accordingly, it is possible to have the same amount of change in the blue light and the green to red light even with respect to the change in illumination in the depth direction.

Accordingly, with this composition, lighting light that is nearly parallel light is obtainable. Through this, it is possible to efficiently light the document and it is possible to obtain a bright image even when the distance from the document is separated, because the light amount change is small in the depth direction of the imaging optical system. Furthermore, when the LED light source is a white LED that obtains white light by blending secondary light from a yellow fluorescent material with a blue light-emitting diode as the light source, because the light-emission regions differ, differences arise in directionality between the blue light and the green to red light, but through the light guide plate **400**, it is possible to accomplish uniformity in directionality. Through this, it is possible to make the amount by which the illumination distribution in the sub-scanning direction changes in the depth direction the same regardless of the color of light.

The LED substrate **230** and light guide plate **400** are respectively anchored to the cylindrical parabolic mirror **20** by a position-determining pin **231** and a light guide plate supporter **405**, and the positional relationship thereof is maintained.

Seventh Preferred Embodiment

FIG. **16** is a light path diagram of the sub-scanning direction cross-section according to a seventh preferred embodiment of the present invention. In this seventh preferred embodiment, a scatterer **410** is disposed covering the light guide plate exit surface **402**, adjacent to the light guide plate

11

exit surface **402**. Here, the scatterer **410** has a thin plate shape and embossing or bead application processing is implemented on a sheet surface made of resin and/or the like. In addition, as the scatterer **410**, it would be fine to utilize one in which direct embossing or bead application processing has been done on the light guide plate exit surface **402**.

FIG. **17** is an example of the sub-scanning direction illumination distribution (a) and the illumination change in the depth direction (b) when there is no scatterer **410** and the light guide distance of the light guide plate **400** (the distance between the incident surface and exit surface) is short. With the light guide plate **400**, light emitted from the LED chips **410** is reflected by a light guide surface **403**, and standardization of directionality of the emitted light and uniformity of the light intensity at the light guide exit surface are accomplished with multiple reflections. When the light guide distance is short, the number of reflections by the light guide surface **403** is small and light emitted from the light guide has a directional distribution in accordance with the number of reflections. As a result, the sub-scanning direction illumination distribution becomes a wavy distribution in accordance with the above-described number of reflections in the sub-scanning direction, as shown in FIG. **17(a)**, and the lighting light proceeds in the depth direction **13** while gradually widening in the sub-scanning direction **12**. Consequently, the change in illumination in the depth direction **13** at a position 0 mm in the sub-scanning direction has wavy changes, as shown in FIG. **17(b)**. Consequently, the lighting illumination achieves non-monotone change even with white paper documents whose distance from the document surface to the top glass sheet **3** changes continuously. As a result, a shading distribution occurs in the scanned image.

With the seventh preferred embodiment, because the scatterer **410** is positioned covering the light guide plate exit surface **402**, adjacent to the light guide plate exit surface **402**, the directional distribution of the light guide exit light is eased or is converted into a substantially even scattering distribution by the scatterer **410**. Consequently, light that has passed through the scatterer **410** has a smooth directionality distribution. As shown in FIG. **17(c)**, the sub-scanning direction illumination distribution is no longer a wavy distribution, and as a result, monotone illumination changes occur in the depth direction, as shown in FIG. **17(d)**. Through this, it is possible to scan with a monotone density change white paper documents in which the distance from the top glass sheet **3** to the document surface continuously changes. If there is this kind of monotone density change in the depth direction, it is possible to reproduce the original density distribution of the document with simple corrections.

Eighth Preferred Embodiment

FIG. **18** is a cross-sectional view of a lighting unit according to an eighth preferred embodiment of the present invention. With the lighting unit according to the eighth preferred embodiment of the present invention, a cylindrical parabolic block **30**, which is a solid block in which a cylindrical parabolic mirror **20** is made of transparent resin, and a light guide plate **400** are formed as a single body. Similar to the eighth preferred embodiment, the cylindrical parabola focal position **23** is at the exit surface **402** of the light guide plate **400**. Hence, the light guide exit surface **400** is equivalent to the joining position of the light guide plate **400** and the cylindrical parabolic block **30**. Because the cylindrical parabolic block **30** and the light guide plate **400** are formed as a single body as described above, the light guide exit surface **402** does not exist as a physical surface. Light emitted from the LED

12

chip **210** is incident on the light guide plate **400**, passes through the light guide exit surface **402** toward the cylindrical parabolic mirror **20** and is incident on the cylindrical parabolic block **30**. Light rays internally reflected by the cylindrical parabolic mirror **20** are projected onto the lighting region **104** from the cylindrical parabolic block exit surface **32** as substantially parallel light rays.

It is possible to emit light rays without changing the angle of the light rays reflected by the cylindrical parabolic mirror **20** by forming the cylindrical parabolic block exit surface **32** into a prism shape comprising a surface substantially parallel to and a surface substantially orthogonal to the light rays reflected by the cylindrical parabolic mirror **20**.

Accordingly, with this composition, positioning the emission exit positions of the light guide plate and the parabolic mirror is possible by integrated formation, and it is possible to eliminate variances caused by assembly.

Ninth Preferred Embodiment

FIG. **19** is a sub-scanning direction cross-sectional view of a lighting unit according to a ninth preferred embodiment of the present invention. In the ninth preferred embodiment of the present invention, an LED substrate **230** comprises a reflective sheet **232** that is all or a portion of the region in which LED chips **210** are not mounted on the surface in which the LED chips **210** are mounted. Through this composition, it is possible to guide a portion of the light hitting the LED substrate **230** to the lighting region **104**, such as lighting light rays **106** from the LED light-emission region not at the focal position of the cylindrical parabolic mirror **20**, out of light emitted from the LED chips **210**, so it is possible to efficiently light a document.

Here, it would be fine for the reflective sheet **232** to reflect the wavelength of light emitted from the LED chips **210**, and it is possible to use a metal plate such as an aluminum plate and/or the like, or a resin scattering sheet and/or the like. When a metal plate such as an aluminum plate and/or the like is used, it is possible for this to also be used as a heat-radiating body that dissipates heat generated from the LED chips **210**.

Tenth Preferred Embodiment

FIG. **20** is a perspective view of a lighting unit according to a tenth preferred embodiment of the present invention. The lighting unit according to the tenth preferred embodiment is provided with a reflective mirror **300** at both ends of the cylindrical parabolic mirror **20** in the main scanning direction. The cylindrical parabolic mirror **20** does not have curvature in the main scanning direction. Consequently, when there is no reflective mirror **300**, the portion of the light rays emitted from the LED array **220** in the main scanning direction progresses without refracting, and progresses to the outside of the lighting unit **2** from the end surfaces of the cylindrical parabolic mirror **20** in the main scanning direction. As a result, these light rays reach the outside of the scan line **8** of the document **7** (see FIG. **1**) in the main scanning direction and are not effectively utilized as lighting light. Hence, by providing the reflective mirror **300**, light progressing to the outside of the cylindrical parabolic mirror **20** in the main scanning direction is reflected and through this it is possible to effectively utilize the light as lighting light by returning a portion of the light to the scan line **8** of the document **7**.

FIG. **21** is a drawing showing the illumination distribution at the main scanning direction end according to the tenth preferred embodiment of the present invention. In this drawing, the horizontal axis is the main scanning direction and

13

shows the positions of the LED **210a** of the corresponding LED array **220** and the end LED **210b** positioned at the main scanning direction end. When there is no reflective mirror **300**, because a large amount of light leaks to the outside from the end LED **210b**, illumination in the main scanning direction decreases toward the end to the inside of the end LED **210b**. On the other hand, when there is a reflective mirror **300**, it is possible to increase the lighting light amount at the main scanning direction end by reflecting light progressing to the outside in the main scanning direction. As a result, by providing the reflective mirror **300**, it is possible to lengthen the region where the main scanning direction illumination is constant to close to the end LED **210b**.

Accordingly, through this composition it is possible to increase the lighting light amount of the main scanning direction end, and thus it is possible to effectively shorten the length of the lighting unit in the main scanning direction.

Eleventh Preferred Embodiment

FIG. **22** is a perspective view of an image scanner according to an eleventh preferred embodiment of the present invention. In addition, FIG. **23** is a sub-scanning direction cross-sectional view of a lighting unit according to the eleventh preferred embodiment of the present invention. The image scanner according to the eleventh preferred embodiment of the present invention is the lighting unit of the first preferred embodiment of the present invention, provided with heat-radiating plates. With this preferred embodiment, plate-shaped heat-radiating plates **50** formed of metal such as aluminum on the opposite surface as the mounting surface of the LED chips **210** of the LED array **230** are positioned adhered to the LED substrate, as shown in FIGS. **22** and **23**. In addition, the cylindrical parabolic mirror **20**, the LED substrate **230** and the heat-radiating plates **50** are joined into one body by joining screws **51**.

As shown in FIG. **22**, the image scanner according to the eleventh preferred embodiment comprises imaging optical system position-determining protrusions **1a**, lighting system position-determining protrusions **50a**, imaging optical system position-determining holes **52a** and lighting system position-determining holes **52b**. The imaging optical system position-determining protrusions **1a** are provided in the imaging optical system **1**. The lighting system position-determining protrusions **50a** are provided in the heat-radiating plates **50**. The imaging optical system position-determining holes **52a** and the lighting system position-determining holes **52b** are provided in structural support plates **52**. The imaging optical system position-determining protrusions **1a** interlock into the imaging optical system position-determining holes **52a**, and the lighting system position-determining protrusions **50a** interlock into the lighting system position-determining holes **52b**. Through this, the imaging optical system **1** and the lighting unit **2** are anchored.

The heat-radiating plates **50** are adhered and attached to the LED substrate **230** on the surface opposite the mounting surface of the LED chips **210** of the LED substrate **230**. Through this, heat generated by the LED chips **210** is efficiently discharged to the heat-radiating plates **50** and increases in the temperature of the LED chips **210** are controlled. As a result, stable operation of the lighting unit and the image scanner becomes possible.

In addition, only a portion of the heat-radiating plates **50** abuts the housing and half is separated from the housing, so that heat from the LED chips **210** does not reach the housing. Accordingly, light receptors provided in the bottom of the housing do not experience an increase in temperature, so it is

14

possible for the light receptors to receive image information from the document **7** with good sensitivity.

It would be fine for the heat-radiating plates **50** of the eleventh preferred embodiment of the present invention to be provided in the lighting unit **2** of the sixth preferred embodiment of the present invention. Through this, similar efficacy is obtained.

Twelfth Preferred Embodiment

FIGS. **24** and **25** are respectively sub-scanning direction cross-sectional views of a lighting unit and an image scanner provided with such a lighting unit according to a twelfth preferred embodiment of the present invention. The image scanner according to the twelfth preferred embodiment comprises a top glass sheet **3**, a lighting unit **2**, first lens mirrors **507**, flat mirrors **508**, apertures **509**, openings **510**, second lens mirrors **511**, sensor ICs **512**, a first sensor substrate **513a**, a second sensor substrate **513b**, signal processing ICs (ASIC) **514**, electronic components **515**, a housing **516** and a bottom plate **517**.

The top glass sheet **3** is a transparent glass plate that supports a document **7** such as literature, media and/or the like. The lighting unit **2** is the same as the lighting unit **2** according to the eleventh preferred embodiment, is a unit for accomplishing linear lighting on the surface of the document, and comprises LED chips **210**, an LED substrate **230**, heat-radiating plates **50** and a cylindrical parabolic mirror **20**.

The LED chips **210** are light sources for shining light. The LED substrate **230** is a substrate to which the LED chips **210** are anchored and which is provided with wiring for supplying electric current to the LED chips **210**. The heat-radiating plates **50** receive heat generated by the LED chips **210** via the LED substrate **230** and dissipate this heat into the air. The cylindrical parabolic mirror **20** has a mirror surface that causes light generated by the LED chips **21** in the direction of the document supported by the top glass sheet **3** to be reflected as approximately parallel light.

The first lens mirrors (also called the first lenses) **507** are concave first lens mirrors that receive divergent light from the document **7**. The flat mirrors **508** receive approximately parallel light from the first lenses **507** and reflect this light. The apertures **509** receive approximately parallel light from the flat mirrors **508**, block light at the periphery and restrict the light passing through. The openings **510** are provided on the surface of the apertures **509** or close thereto and are a part in which is provided an opening through which light received by the apertures **509** is allowed to pass. The second lens mirrors (also called the second lenses) **511** are concave second lens mirrors for receiving and condensing light passing through the apertures **509**.

The second ICs **512** (also called light receivers) receive light reflected from the second lens mirrors **511** that has passed through the openings **510**, and are sensor ICs (Integrated Circuits) having a MOS semiconductor composition comprising a photoelectric conversion circuit for accomplishing photoelectric conversion and a driver. The first sensor substrate **513a** and the second sensor substrate **513b** are sensor substrates on which the sensor ICs **512** are mounted, and are respectively positioned lined up in the sub-scanning direction, as shown in FIG. **25**. The signal processing ICs (ASIC) **514** are ICs for accomplishing signal processing on signals photoelectrically converted by the sensor ICs **512**. The electronic components **515** are capacitors, resistors and/or the like mounted on the sensor substrates **513**. The housing **516** is a hollow member to which the imaging optical system that is the imaging means comprising the sensor ICs and mirrors is

15

anchored. The bottom plate **517** is a plate-like member covering the bottom opening of the housing **516** and to which the lenses and housing **516** are anchored.

The action of the optical system of the image scanner according to the twelfth preferred embodiment of the present invention will be explained. Light from the LED chips **210** is reflected by the cylindrical parabolic mirror **20** and shines on the document **7** as approximately parallel light. Scattered light reflected by the document **7** is inclined to one side in the sub-scanning direction (in the leftward direction in FIG. **25**) and is reflected as collimated light. Light from the first lens **507** is reflected to the flat mirror **508** inclined to one side in the sub-scanning direction. Light from the flat mirror **508** shines on the window (opening **510**) of the aperture **509** as approximately parallel light rays. Furthermore, light radiating from the window **510** is reflected to the second lens **511** inclined to one side in the sub-scanning direction, and because this light is incident on the sensor IC **512** for each beam, the image information is imaged as an inverted image on the light-receiving surface of the sensor IC **512**.

Scattered light shining from the left-side lighting unit **2** and reflected by the document **7** that is the subject of illumination is inclined toward the other side (the left direction in FIG. **25**) in the sub-scanning direction, and is incident on the sensor IC **512** on the first sensor substrate **513a**. Scattered light shining from the right-side lighting unit **2** and reflected by the document **7** that is the subject of illumination follows a light path symmetrical to the light path shown in FIG. **25** on a plane orthogonal to the sub-scanning direction and is incident on the sensor IC **512** on the second sensor substrate **513b**. Consequently, the light path incident on the sensor IC **512** mounted on the first sensor substrate **513a** and the light path incident on the sensor IC **512** mounted on the second sensor substrate **513b** do not intersect and thus it is possible to prevent light ray interference in the light path.

In the twelfth preferred embodiment of the present invention, the lighting unit **2** explained in the eleventh preferred embodiment of the present invention is used, but similar efficacy and results are obtained by using the lighting unit explained in the first through tenth preferred embodiments of the present invention.

Having described and illustrated the principles of this application by reference to one or more preferred embodiments, it should be apparent that the preferred embodiments may be modified in arrangement and detail without departing from the principles disclosed herein and that it is intended that the application be construed as including all such modifications and variations insofar as they come within the spirit and scope of the subject matter disclosed herein.

This application claims the benefit of priority based on Japanese Patent Application No. 2011-234076, filed on Oct. 25, 2011, the entire disclosure of which is incorporated by reference herein.

REFERENCE SIGNS LIST

1 Imaging optical system, **1a** Imaging optical system position-determining protrusion, **2** Lighting unit, **3** Top glass sheet, **4** Substrate, **7** Document, **8** Scan line, **11** Main scanning direction, **12** Sub-scanning direction, **13** Depth direction, **20** Cylindrical parabolic mirror, **21** Semi-cylindrical parabola y+, **22** Semi-cylindrical parabola y-, **23** Cylindrical parabola focal position, **24** Cylindrical parabola vertex, **25** Cylindrical parabola axial plane, **30** Cylindrical parabolic block, Cylindrical parabolic block incident surface, **32** Cylindrical parabolic block exit surface, **40** Imaging element, **50** Heat-radiating plate, **50a**

16

Lighting system position-determining protrusion, **51** Joining screw, **52** Structural support plate, **52a** Imaging optical system position-determining hole, **52b** Lighting system position-determining hole, **101** Imaging optical axis, **102** Lighting optical axis, **103** Lighting light rays, **104** Lighting region, **105** Central axis in light-emission direction, **210** LED chip, **211** LED package, **212** Blue light-emitting diode, **213** Yellow fluorescent material, **214** Blue light-emitting diode short axis, **215** Blue light-emitting diode long axis, **216** LED package top surface, **217** Yellow fluorescent material strong light-emission region, **218** LED light-emission region, **210**, **210a**, **210b** LED chip, **220** LED array, **230** LED substrate, **231** Position-determining pin, **232** Reflective sheet, **300** Reflective mirror, **400** Light guide plate, **401** Light guide plate incident surface, **402** Light guide plate exit surface, **403** Light guide surface, **405** Light guide plate supporter, **410** Scatterer, **507** Concave first lens mirror (first lens), **508** Flat mirror, **509** Aperture, **510** Opening, **511** Concave second lens mirror (second lens), **512** Sensor IC (light receiver), **513** Sensor substrate, **513a** First sensor substrate, **513b** Second sensor substrate, **514** Signal processing IC (ASIC), **515** Electronic components, **516** Housing, **517** Bottom plate

The invention claimed is:

1. A lighting unit, comprising:

a light source in which light-emitting elements are positioned in an array in a main scanning direction;
a parabolic mirror that projects light emitted from the light source on an illumination region of an illuminated item; and
a housing that houses or supports the light source and the parabolic mirror;

wherein the parabolic mirror forms a shape in which a cylindrical paraboloid having curvature with respect to a sub-scanning direction has been clipped by an axial plane that is perpendicular to a vertex of the cylindrical paraboloid in the main scanning direction; and
the light source is positioned such that a center or an edge of the light-emitting elements is caused to match a focal position of the cylindrical paraboloid, a central axis in the light-emitting direction of the light-emitting elements being perpendicular to the axial plane.

2. The lighting unit according to claim **1**, wherein:

the light-emitting elements of the light source are disposed in a surface facing the parabolic mirror on a light source substrate positioned parallel to the axial plane; and
the light source substrate is anchored at a predetermined position of the parabolic mirror by position-determining pins.

3. The lighting unit according to claim **1**, wherein:

the light source is a white LED that obtains white color by blending secondary light from a yellow fluorescent material, with a blue light-emitting diode as the light-emitting element; and
a short axis direction of chips of the blue light-emitting diode is positioned so as to be parallel to the main scanning direction.

4. The lighting unit according to claim **1**, wherein:

the light source is a white LED that obtains white color by blending secondary light from a yellow fluorescent material, with a blue light-emitting diode as the light-emitting element; and
an area of blue light-emitting diode chips on the vertex side of the parabolic mirror matches the focal position of the parabolic mirror.

17

5. The lighting unit according to claim 1, wherein the parabolic mirror is formed of a solid transparent material.

6. The lighting unit according to claim 1, further comprising a light guide plate for guiding light emitted from the light source;

wherein the parabolic mirror shines light via the light guide plate emitted from the light source on the illumination region of the illuminated item; and

the housing stores or supports the light source, the light-guide plate and the parabolic mirror.

7. The lighting unit according to claim 6, wherein a scatterer for scattering light is disposed between the light guide plate and the parabolic mirror.

8. The lighting unit according to claim 6, wherein the parabolic mirror is formed of a solid transparent material and is formed as a single body with the light guide plate.

9. The lighting unit according to claim 2, wherein a reflective sheet is provided in an area other than a light source mounting area of a light source mounting surface of the light source substrate.

10. The lighting unit according to claim 1, wherein a reflective mirror is provided at an end of the parabolic mirror in the main scanning direction.

18

11. An image scanner, comprising:

the lighting unit according to claim 1;

an imaging optical system on which scattered light from light reflected by a document in the illumination region of the illuminated item is incident, and which images an image of the illuminated item in a light receptor extending in the main scanning direction; and

a housing for housing or supporting the lighting unit, the imaging optical system and the light receptor;

being an image scanner for scanning the document relative to the sub-scanning direction orthogonal to the main scanning direction and obtaining image information of the illuminated item; and

wherein the lighting unit is positioned on both sides of an optical axis of the imaging optical system in the main scanning direction.

12. The image scanner according to claim 11, wherein the lighting unit is positioned such that an illumination direction of light exiting from the lighting unit is symmetrical with respect to the optical axis of the imaging optical system.

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